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INFORMATION SUPPLEMENT
TO
REVISED ARROW PROGRAM STATEMENT OF WORK BROCHURE AD-53 ISSUE 2

This Information Supplement contains the following material to amplify and assist in the interpretation of the Statement of Work for the Revised Arrow Program (Brochure AD-53 Issue 2) and its accompanying Cost Supplement:-

SECTION 1 - Charts.

This section contains the following chart information on the program:-

Manpower:

Avro Aircraft Limited manpower during the period of the 37-aircraft Arrow program is shown broken down into hourly direct, monthly direct, and overall Company manpower.

Cost-Time Curves:

The split and relative time phasing of development costs and engineering support to production are shown on this curve.

Arrow 2 Development Schedule Summary:

This chart shows the time scale of engineering to bring the Arrow 2 from the 25206 configuration to the operational configuration of 25221, along with the flight test period and the inception of the formal ECP procedure.

SECTION 2 - Report 72/PROJ 7/18.

This report presents the following information:-

(1) Discussion of basic airframe problem areas, including tentative lists of modifications for problem areas which have been identified.

(2) Outline of test program for the basic airframe.

(3) MA-1C/Genie/Falcon installation provisions, together with a preliminary definition of the MA-1C electronic system.

(4) Outline of test program for the MA-1C electronic system and the Genie/Falcon weapon pack.

(5) Summary of flight test instrumentation requirements for the aircraft allocated to contractor and RCAF/Avro flight testing (25201 through 25220).

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SECTION 3 - List of Arrow program reductions and deletions.

SECTION 4 - AWSCC Report No. 11 "Interim Report on Training Requirements, Avro and Orenda Personnel".

This document explains the requirement for contractor training on the various Government-furnished and contractor-furnished major sub-systems, and presents tentative data on schedules and number of personnel requiring training.

SECTION 5 - Performance Report No. 15.

This report gives the performance for the operational version of the aircraft (25221) with Iroquois engine to Orenda Model Specification EMS-8.

SECTION 6 - Performance Report No. 15A.

This document gives the performance for the basic Arrow 2 airframe (25206) with its initial engine equivalent to Iroquois #116.

SECTION 7 - Performance Report No. 15B.

This report describes the performance of the 25206-type aircraft with Iroquois engine #124.

SECTION 8 - Follow-on engineering and flight test costs.

This lists anticipated costs for engineering and flight testing activities which will have to continue beyond the September 30, 1960 cut-off date of the engineering program presented in AD-53 Issue 2.

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ARROW REVISED PROGRAM

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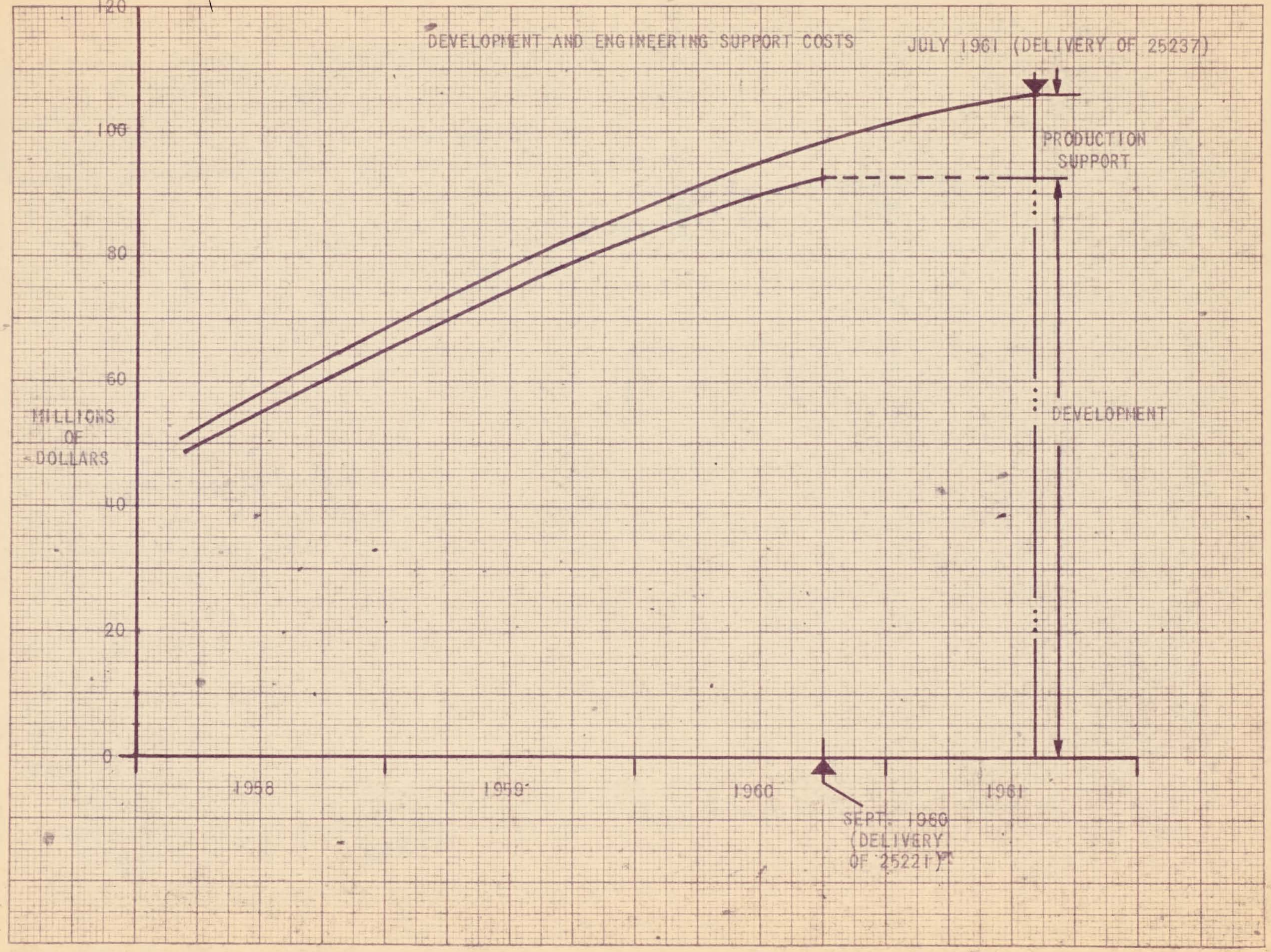

TOTAL COMPANY MANPOWER

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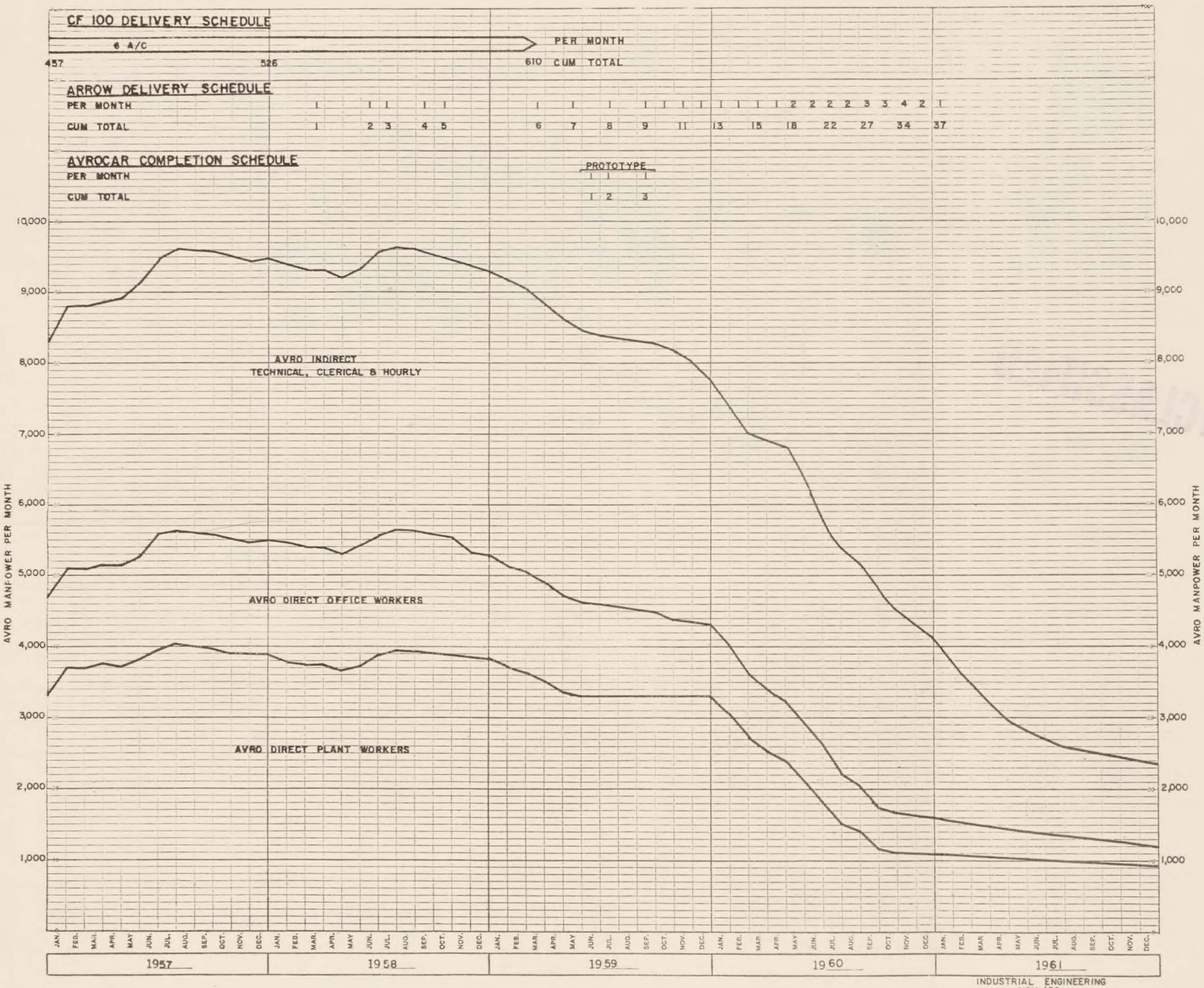

INDUSTRIAL ENGINEERING
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INTRODUCTION

This report outlines the requirements for changes and additions to bring the standard of the ARROW 2 aircraft to that required for operational use.

The first ARROW 2 aircraft 25206 is being manufactured to an Engineering Release which has been frozen. In consequence, the capability of this aircraft was defined by the state of knowledge with respect to the project at the time of freezing of the Engineering Release. Certain obvious additions must be made to bring the aircraft up to an operational standard in that 25206 is an unarmed aircraft with provisions for instrumentation to permit it to take its place in the development program. Consequently, changes to introduce an electronics system and an operational weapon pack must be made.

Less obvious perhaps is the need for a significant number of small changes necessary to ensure the airworthiness and operational capability of the basic airframe. However, consideration of this point will show the frozen engineering record for this aircraft can only contain the fruits of experience gained in the development programs prior to the freeze date of the engineering and, in fact, since there is a significant lead-time in the preparation of drawings, specifications, etc., for release to Manufacturing, the status of the Engineering Release for aircraft 25206 represents that of a comparatively early stage in the development program.

In addition to discussing the changes to hardware, this report presents an outline of the testing programs necessary to achieve the objectives of the program. In the main these testing programs are concerned with demonstration of adequate structural integrity, demonstration of adequate performance and with the accumulation of an adequate history of flying time to ensure that the aircraft can enter operational use. During the course of this testing it is the intention to introduce changes to eliminate such deficiencies in aircraft or system functioning as become apparent.

The report is presented in five parts, as follows:

1. Discussion of problem areas.
2. An outline of the test program required for the basic airframe.
3. Description of provisions for the installation of the MA-1 system, the installation of the Falcon and MB-1 weapons and a system definition.
4. An outline of the test program for the MA-1/MB-1/Falcon installation.
5. An outline of instrumentation provisions in flight test aircraft.

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SECTION 1

PROBLEM AREAS - AIRFRAME

PROBLEM AREAS -- BASIC AIRFRAME

The capabilities of the first ARROW 2, Serial No. 25206, are controlled by the standard of the presently frozen Engineering Release for this aircraft. Since the majority of this release took place some time ago the flight development program since that time has revealed certain deficiencies , the rectification for which has not been incorporated in 25206. Over and above this, the flight development program is still in the exploratory stage and it has not yet been possible to fly the aircraft through the complete flight envelope. In consequence, it is probable that as probing continues further deficiences and problem areas will become apparent. The following discussion uses the capability of 25206 as frozen and as described in Model Specification 72/MS/1, as the base line.

1.1 Stability & Control.

The significant known problem areas in this field are with respect to the performance of the emergency flying control system and with respect to the development of the manual mode control stick steering system. The emergency flying control system, i.e. control through the normal cables and linkages directly to the servo valves on the controls. has been shown to have unacceptable phase lags present. For example, the pitch control is such that with increasing indicated speed the system quickly shows characteristics which are unacceptably sensitive. Flight with this elevator system under ideal conditions, in the hands of an experienced pilot, has been possible up to 460 knots EAS. However, the control is not considered to be suitable for use by a normal service pilot at speed in excess of 375 knots EAS. Aircraft in the flight development program fitted with a modified elevator system have recently shown a dramatic improvement in this situation and it is confidently expected that similar techniques applied to the aileron system will be equally successful.

System development of the control stick steering mode with control command being generated as stick force and fed through the damping system to the command servos, is proceeding satisfactorily but its pace is perforce governed by the development status of the emergency system. It should be noted that no attempt has yet been made to activate the various limiter modes (roll rate, aileron limiter, G limiter, command signal limiter).

1.2 Structural Integrity.

Two problems areas with respect to structural integrity are presently known. The first of these is the integrity of the nozzles. The ARROW 2 employs fixed convergent/divergent nozzles similar in design to the ARROW 1A nozzles. It has been shown that these are unable to resist the combined temperatures and structural loads in flight with the afterburners in operation and there is no reason to believe that the ARROW 2 nozzles will fare any better.

1.2 Structural Integrity (Cont'd)

Flight testing of the ARROW 1 aircraft has shown that the main landing gear doors as installed on 25206 are not capable of withstanding the applied air-loads at speeds in excess of 500 knots EAS.

Over and above these two areas the routine testing of the structure in static test rigs has shown the need for a number of small changes to the structure of 25206 to permit it to demonstrate adequate structural integrity. The structural test program is not yet complete.

Significant structural problems were found in the landing gears designed for 25206. As frozen, the design includes a modification to the main landing gear units with its detail dictated by expediency rather than by cost and efficiency. A program is under way to introduce a more practical main landing gear into the ARROW 2.

1.3 Aircraft Systems.

In general the position with respect to aircraft systems is good although a number of minor problem areas are known to exist. These are outlined as follows:

1.3.1 Undercarriage, Wheels and Brakes.

Aircraft operational experience dictates the need for installation of nose wheel steering and mainwheel anti-skid systems.

The static testing of the nose leg has shown that the deflection of the suspended link results in a foul of the liquid spring cylinder on the main fitting. To clear this foul the fitting requires strengthening.

Development has indicated requirements for grease seal and uplock release jack modifications.

It is to be expected that reliability requirements will result in further changes as experience grows. In particular this applies to the locking indication system.

Aircraft 25206 will be fitted with ARROW 1 wheels, tires and brakes as an expedient. Units designed to meet the requirements for the ARROW 2 will be introduced into the line upon availability.

1.3.2 Hydraulic System

Experience has shown the necessity of splitting the brake systems to avoid the present unsatisfactory condition of an emergency brake line failure dumping the whole system.

There are several cases in this system of the use of ARROW 1 equipment as an expediency. Modifications will be required to introduce the proper units.

Maintenance and reliability aspects require to be improved in the access to filters, accumulators, compensators and nitrogen bottle; by eliminating, if possible, the connection between the flying controls and utility systems at the compensators; by introducing forged body filters; and by miscellaneous changes to increase reliability, i.e. elimination of pipe fouls, etc.

1.3.3. Fuel System

Modifications of a minor order as a result of tests to the drop tank installations are to be expected, particularly in the breakaway functions. The fuel vent outlets must be repositioned away from the missile blasts. Experience has indicated that the gauging system is sensitive to shielding problems and needs improvement.

In this system as well ARROW 1 equipment units used as expediencies require replacement.

Some improvement to the function of the low level warning, the defuelling provisions (among other points) is required. Changes to make possible the use of more of the residual fuel are necessary.

1.3.4 Power Plant and Associated Systems.

The installation of the Model Specification Iroquois engine will be the subject of a modification. Both Orenda and Avro flight testing will probably indicate requirements for modifications to achieve an acceptable installation. Experience to date indicates that detailed development of the bypass and ejector systems may be necessary.

The constant speed drive and engine performance indication systems will be the subject of minor modifications - the former resulting from a change in supplier, the latter a system introduction.

An engine oil level indication system is under investigation at this time for future installation.

1.3.5 Air Conditioning and Oxygen

It is to be expected that the cockpit insulation will be the subject of modification to be fully flightworthy. A requirement exists for separating the emergency and regular oxygen supplies. Experience with the ARROW 1 system would suggest the need for miscellaneous changes as a result of flight development.

The oxygen consumption indication system is under discussion with the Institute of Aviation Medicine, and it may be necessary to introduce some changes in this area. The requirement for the installation of an adequate leak detection system for the air conditioning bleed lines has not yet been solved. A method of temperature control on ground supply is necessary for maintenance purposes.

Under development at this time are mass flow controllers and a cockpit bypass system to maintain pressure at idling condition. Study indicates that modifications are extensive, and it is proposed to re-assess the requirement.

1.3.6 Electrics

Both the illumination and control of the master warning system are deficient at this time and require rework to become acceptable There will be a great many miscellaneous electrical changes introduced both from the reliability standpoint and in conjunction with changes to other systems.

1.3.7 Miscellaneous

One of the most serious problem areas at present is in the Parabrake System in its operation, function, rigging and inspection facilities, and in the parachute itself.

The escape system requires improvements such as linked ejection; arm, leg, and head restraint; and dual emergency cartridges.

The fuel pump mechanical drive systems are to a limited standard and will be replaced with improved shafts and splines for better life and easier adjustment. The operational cockpit lighting system requires study.

The engine intake de-icing boots are not in an acceptable condition at this time. Either an intensive program or a re-evaluation of the requirement is indicated. In any case a re-assessment is necessary.

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SECTION 1

APPENDIX 1

This appendix lists, in the form of tentative modification titles, such changes as have been shown to be necessary as a result of the program to date. Although these changes deal with problem areas so far detected it is not yet certain that in every case the proposed change provides the solution, nor of course is it established that problem areas so far detected are by any means the total that will have to be dealt with.

For the purpose of this listing modifications have been segregated into four groups as follows:

(A) Changes beyond the present standard of 25206 to achieve a minimum operational aircraft, plus airworthiness requirements arising from the development program.

(B) Engineering previously committed to replace or modify equipment used as expedients due to qualification or development status.

(C) Present or expected requirements to achieve an adequate maintenance and reliability status and to assist manufacture.

(D) Modifications which are now under consideration for product improvement over and above the minimum operational product as defined in A, B, and C above. (RCAF and DDP approval will be required for these changes before expenditure of engineering funds.)

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APPENDIX I

100 FLYING CONTROL SYSTEM

A	101	Repositioned parallel servos (Aileron & Elevator)
A	102	Elimination of Control Valve Boosters
A	103	Installation of Pitch Axis Stick Gearing
A	104	Altered Control Feel Characteristics Associated with Other Modifications and reduction in Elevator Sensitivity ratio.
C	105	Improved Control Valves
C	106	Reduction of Actuator Bore size
A	107	Production version of Valve Dampers
C	108	Internal surface gust locking
C	109	Dual Motor Feel and Trim Units
A	110	Increase in stick stiffness
A	111	Miscellaneous detail design modification required to Eliminate backlash and fouling conditions and to avoid catastrophic maintenance errors (i.e. reversed hydraulic lines and cables), plus detail changes resulting from remaining Flying Control system development flying program.

200 DAMPING SYSTEM

B	201	Amp-Cal Repackaging and redesign (simplification)
B	202	Function-Selector re-design - elimination of manual landing mode selection (RCAF Request)
B	203	Sensor modifications - Roll rate limiter repackaging. - Addition of thumper solenoids. - Replacement of three Phase gyros with single phase.

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200	Continued/	
B	204	Heater Pick-offs from separate contact breaker
B	205	Production Electronic Filters
C	206	"Dry Torque" servo motor Installations
A	207	Improvement to stick force transducer
A	208	Installation of Yaw monitor accelerometer
A	209	Functioning of 'G' Limiter
A	210	Functioning of Roll-Rate Limiter
A	211	Functioning of Command Signal Limiting
A	212	Functioning of aileron limiter
A	213	Damper modifications required as a result of flying controls development
B	214	Alterations made necessary by qualification testing (NOTE: This modification in total represents the production damper)
300	<u>UNDERCARRIAGE, WHEELS & BRAKES</u>	
B	301	Installation of MK.2 Main Undercarriage
A	302	Installation of new nose leg fitting required as a result of liquid spring deflection
A	303	Installation of landing lamps
A	304	Installation of anti-skid
A	305	Installation of nose wheel steering
B	306	Installation of Goodrich tires, wheels and brakes (Axle change required)
A	307	Installation of improved uplock release jacks and restrictors.

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300 Continued/

A	308	Miscellaneous changes to increase reliability of Undercarriage locking
A	309	Improvement to grease seals

400 STRUCTURE

A	401	Addition of Main wheel pivot door Pick-Up on Leg
A	402	Improvements to main wheel door and fairing rigging
A	403	Improvements to wing jacking points
A	404	Strengthening of Tanks 3 and 4
D	405	Elevator Control Box Strengthening
C	406	Improvement to engine bleed line bracketry
C	407	Acoustic damping of intake side skins
A	408	Redesign of Tail cones to increase resistance to thermal stress
A	409	Miscellaneous redesigns required as a result of future structural test results both static and flight.
C	410	Miscellaneous detail changes to assist manufacture.

500 HYDRAULICS

C	501	Improved access to filters, accumulators, compensators, and nitrogen bottle.
B	502	Replacement of various items of Arrow 1 equipment required for early aircraft
C	503	Installation of forged body filters
A	504	Increased brake system reliability obtained by splitting systems
C	505	Elimination of connection of flying controls and utility system of compensators.

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500 Continued/

C	506	Miscellaneous changes to increase reliability, i.e. removal of pipe fouls etc.

600 FUEL SYSTEM

A	601	Modifications to Drop Tank provisions as shown required by test
C	602	Alterations to provide use of residual fuel
C	603	Improvement to defuelling provisions
D	604	Replacement of float type fuel-no-air valve with new design
B	605	Replacement of Arrow 1 fuel pumps
A	606	Repositioning of fuel vent outlets out of armament blast
A	607	Improvement to gauging system shielding

700 POWER PLANT AND ASSOCIATED SYSTEMS

A	701	Installation of Model Specification Iroquois engine
B	702	Replacement of Sundstrand with G.E. constant speed drive.
B	703	Installation of engine performance indication system
C	704	Installation of Oil level indication system
A	705	Miscellaneous modifications as a result of O.E.L. and AVRO flight tests.
	706	Detail development of by-pass and ejector systems.

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800	AIR CONDITIONING AND OXYGEN	
C	801	Installation of leak detection system
B	802	Replacement of AVRO temperature controllers with production units.
C	803	Ground Rig Temperature Control System
D	804	Installation of Mass Flow Controller
C	805	Oxygen Consumption indication system
A	806	Improvements to cockpit insulation
A	807	Separation of emergency and regular oxygen supply
D	808	Incorporation of cockpit by-pass
A	809	Miscellaneous air conditioning modifications as a result of flight development.
900	ELECTRICS	
A	901	Improvement to master warning system (illumination and control)
A	902	Miscellaneous electrical changes as a result of reliability investigations
	903	Miscellaneous electrical changes resulting from other airframe system changes.

1000 MISCELLANEOUS

C	1001	Improvement to pump mechanical drives
A	1002	Improvement to parabrakes and controls
C	1003	Improvement to fire bottle maintenance
D	1004	Redesign of Intake De-icing boots to overcome assembly tolerance problems.
C	1005	Incorporation of relevant change requests from the Arrow 2 mock-up conference.
C	1006	Engineering of operational cockpit lighting system
A	1007	Escape System Improvements to escape system including engineering of: (a) linked ejection system (b) arm, leg and head restraint development (c) dual emergency cartridges

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GROUND AND FLIGHT TESTING

To support the airframe development the following basic testing is required:-

1.0 GROUND TESTING

1.1 Structural Tests

1.1.1 Completion of testing of static test airplane including:

(a) Rolling pull-out case

(b) Symmetric case

(c) Elevator control box fatigue

(d) Undercarriage door and uplock tests

(e) Undercarriage spring back case.

1.1.2 Completion of testing of remaining components listed in Appendix 1 of AD.53 including:

(a) Drop tank

(b) Engine Intake Transition Duct

(c) Engine Bay Access Door

1.1.3 Miscellaneous detail testing of structural joints etc. in support of control box life investigations and similar areas of the basic airframe.

1.1.4 Special structural testing to resolve accoustic and thermal problems of the basic airframe including:

(a) Transient heating tests on wing boxes

(b) Thermal tests on typical Arrow fuselage frames and joints.

(c) Accoustic testing on tailcone and stinger panels.

(d) Accoustic testing on typical Arrow skin panels and structures.

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1.0 Continued/

1.1.5 Control box fatigue testing and deflection tests on B.1 rig.

1.2 System tests

1.2.1 Completion of testing of airframe sub-systems to determine functioning and life including:-

1.2.1.1 Fuel system

(a) Refueling

(b) Defueling

(c) Pressure Build-up

(d) Normal transfer operation

(e) Dynamic cases

(f) Mission cases

(g) Long range tank operation

(h) Simulated failure cases

(i) Trouble shooting.

1.2.1.2 Air Conditioning

(a) Flow Distribution

(b) System operation - steady

(c) System control stability

(d) Emergency control

(e) Operation at Max. temperatures and pressures

(f) System ground servicing

(g) Duct expansion tests

(h) Endurance tests.

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1.2 Continued/

1.2.1.3 Electrics

(a) Individual circuit operation

(b) Voltage loss tests

(c) Simulated flight operations

(d) Power system tests

1.2.1.4 Flying Controls: (B1 rig and simulator)

(a) Completion of development of the pitch, and roll axis

(b) Control valve testing

(c) Control Feel system development

(d) Duty cycle testing - Rudder
Aileron
Elevator

(e) Stick force system development

1.2.1.5 Undercarriage Tests (Completion of)

(a) Main undercarriage functioning tests including cold and hot temperature tests

(b) Main undercarriage doors etc. Hydraulic and electrical system testing

(c) Nose undercarriage functioning tests

(d) Nosewheel steering tests.

1.2.1.6 Miscellaneous

Testing of miscellaneous systems and equipments such as:

(a) Fire extinguishing system distribution checks

(b) Fatigue testing on major hydraulic jacks

(c) Breadboard and rig testing of air conditioning system controls and valves.

(d) Pre-installation checks of certain equipments, fuel-no-air valves, pressure release valves etc.

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2.0 FLIGHT TESTING

2.1 Arrow 1

Flight testing on Arrow 1 aircraft 25201, 25202, and 25204 includes:-

(a) Development of basic airframe control and handling to a minimum operational standard.

(b) Limited structural integrity flights to provide correlation with static test airplane testing

(c) Trial installations of steering, anti-skid systems etc.

(d) RCAF performance testing

(e) Systems performance and reliability

2.2 Arrow 2

Flight testing on Arrow 2 aircraft 25206, 25207, 25208, 25209, and 25214 including:

(a) Development of basic Arrow 2 systems and determination of performance and reliability

(b) Installed airframe/engine development in conjunction with Orenda, plus performance and reliability of ancillary power systems.

(c) Drop Tank system.

(d) Trial installations.

(e) Arrow 2 undercarriage, wheels, brakes and related system development.

(f) Qualitative assessment of Arrow 2 performance.

The above aircraft plus those allocated to armament and Fire control system testing will provide the necessary minimum consolidated block of flying time (1000 Hours) required prior to squadron delivery in order to ensure a reliable and serviceable product.

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CHANGES TO INSTALL WEAPON PACKS AND THE MA-1C SYSTEM INTO THE ARROW 2 (AIRCRAFT # 25206 IS USED AS BASIS)

1.0 STRUCTURE

1.1 Radome

A shortened radome finishing at Stn. 48.20 with re-designed end ring and latch provisions. Electrical properties modified to suit 23" MA-1 antenna.

1.2 Radar Nose

The Arrow 2 structure designed for the ASTRA system replaced by a re-engineered Arrow 1 structure:-

(a) Modified to suit cockpit bulkhead Stn. 120.

(b) Modified forward end to support extension structure for antenna/RF head assembly.

(c) Modified centre shear panel

(d) Access doors modified to clear equipments.

(e) Addition of rack shock mount structures.

(f) Miscellaneous changes to suit wiring etc.

1.3 Front Fuselage

1.3.1 Front cockpit, revisions for new instrument panel, attack scope, console re-arrangement etc.

1.3.2 Rear cockpit, revisions for console re-arrangement, Scope and antenna hand control, H.S.I. mountings etc.

1.3.3 Air Conditioning Bay revisions for mounting motor generator units, power supplies etc.

1.4 Centre Fuselage

Electronics Bay modified to install MA-1 units including :

(a) re-design of rear beam

(b) new fore and aft beams

(c) modified centre access door

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1.5 Duct Bay

Revised equipment mountings on bottom access doors.

1.6 Inner Wing

(a) Bracketry additions on underside of wing for mounting the stable platform.

(b) Revisions to dorsal mountings for I.F.F. equipments.

1.7 Miscellaneous minor changes throughout fuselage for wiring runs etc.

2.0 SYSTEMS

2.1 Air Conditioning

Ducting and distribution changes as required to supply MA-1C components.

2.2 Electrical System

Minor system changes to suit MA-1C power supply units.

2.3 Miscellaneous

Detail changes to low pressure pneumatic system, pitot-static piping, antenna waveguides etc.

3.0 MB-1/FALCON/FUEL PACK

3.1 Structural Changes - to fit the new weapon pack include adding dishes to the bay roof to clear the rear Falcon fins plus miscellaneous bracketry changes to suit the system changes below.

3.2 System changes to match the Pack:

(a) Re-routing of air conditioning pipes and other services to clear MB-1 ejector pistons.

(b) Modifications to air conditioning ducting for pack supply.

(c) Modifications to electrical system for pack supply and disconnect.

(d) Modifications to fuel system for pack fuel tankage including sequence control and fuel capacitance systems.

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PRELIMINARY DEFINITION OF MA-1C ELECTRONIC SYSTEM

RACKS

Unit	Unit # (or Equiv)	# Req'd
Rack, Electronic Equipment Ind.	464002-150	2
Rack, Electronic Equipment HSI	464102-160	1
Rack, Electronic Equipment RCVR-XMTR	464402-150	1
Rack, Electronic Equipment Coder - Decoder	464502-150	1
Rack, Electronic Equipment LH Fwd Compartment	X470073-100	1
Rack, Electronic Equipment Antenna	464173-150	1
Rack, Electronic Equipment RH Fwd. Compartment	X470273-100	1
Rack, Electronic Equipment Aft Compartment, Left	X470074-100	1
Rack, Electronic Equipment Aft Compartment, Right	X470174-100	1
Rack, Electronic Equipment Stable Platform Gen.	464474-150	1
Rack, Dehydrator	464674-151	1
Rack, Dehydrator and Filter	464774-101	1
Rack, Air Data Compensator	464573-150	1
Rack, Air Data Computer	464673-150	1
Rack, Air Data Computer	464773-150	1
Rack, Stable Platform	464374-150	1
Rack, AFCS	464873-150	1
Rack, AAIFF forward		1
Rack, AAIFF aft		1
Rack, Electronic Equipment Cockpit display	464602-150	1
Rack, Electronic Equipment - Altitude	464611-150	1

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RADAR SUB-SYSTEM

System Components	Unit # (Or Equiv)	# Req'd
Filter bandpass 1600 cps	464425-150	1
Synchronizer, Electrical Master Timer	464003-150	1
Synchronizer, Electrical Range Tracking	X470103-100	1
Amplifier, Electronic Control - Az or El Drive	464106-150	1
Amplifier, Electronic Control - Antenna Servo	464206-150	1
Amplifier, Electronic Control - Elevation drive	464506-150	1
Valve, Automatic Regulating, Pressure	464107-150	1
Waveguide Assembly - Radar	464016-150	1
Antenna, Radar	464 17-150	1
Converter, Wave Form - AGC and Angle Track	476020-150	1
Converter, Signal Data - Attack Display	X470223-100	1
Converter, Signal Data - Time Sharing Electronic	464523-150	1
Indicator, Pressure	464024-150	1
Amplifier, Electro Control Azimuth Search Program	464041-150	1
Amplifier, Electro Control El Search Program	464141-150	1
Amplifier - Computer - Antenna Control	464241-150	1
Amplifier - Filter Assembly, - Elect-Steering Signal	X470341-100	1
Compressor, Reciprocating Power Driven - Air	464045-151	1
Computer, Steering Signal	X470346-100	1
Comparator, Signal - AMTI	464150-150	1
Relay, Switch Assy. Radar	464063-150	1

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RADAR SUB-SYSTEM (Continued/

System Components	Unit # (or Equiv)	# req'd
Receiver-Transmitter Radar	X470065-100	1
Amp. Electronic Cont Transmitter Tuning	X470866-100	1
Gate, Electronic - Clutter	464082-150	1
Coupler, Directional, Radar	464084-150	1
Generator, Sweep, Indicator	464389-150	1
Duct Assembly, Receiver, Modulator, Cooling	464190-150	1
Oscillator, Radio Freq. Amp. Sweep Gen. - Ind.	464093-150	1
Video and AZ Sweep	464195-150	1
Amplifier, Video-Tracking Preamplifier	X470095-100	1
Amplifier, Intermediate Frequency	464295-150	1
Amplifier Assy - Attack Display	X470395-100	1
Amplifier, Video Synchronizer AMTI	464495-150	1
Meter, Self Test, Radar	464096-150	1
Relay, Switch Assembly, Self Test Radar	464196-150	1
Dehydrator	463097-100	2

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COMPUTER SUB-SYSTEM

Sub-system Components	Unit # (Or Equiv.)	# Req'd
Interconnecting Box Digital Computer	464318-150	1
Converter, Signal Data AC Inputs	476023-150	1
Converter, Signal Data, Analog Outputs	476123-150	1
Conv., Signal Data, Digital	476323-150	1
Computer, Electronic Digital, Arithmetic	X470146-100	1
Computer, Electronic Digital - Control	476446-150	1
Comparator, Signal - Analog - Digital	476050-150	1
Elect. Switch - Analog Signal Sampling	476051-150	1
Control, Signal Data - Input/output	X470255-100	1
Magnetic Drum, Data Storage	464057-150	1
Memory, Digital - Shift Register	476157-150	1
Amplifier Assembly - Memory, Read-Write	X470457-100	1
Gate Assembly, Diode-Memory, Read	464657-150	1
Relay Assembly - Digital Output - Phase Change	464064-150	1
Generator, Pulse - Clock	X470489-100	1
Test Set, Computer - Digital	464296-150	1

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I.F.F. SUB-SYSTEM

AIR TO GROUND:

Sub-system Components	Unit # (Or Equiv.)	# Req'd
Coder/Decoder, Transponder Set	464028-150	1
Switch, Radio Frequency Transmission Line	464263-150	1
Receiver/Transmitter, Radio	464265-150	1

AIR TO AIR:

Sub-system Components	Unit # (Or Equiv.)	# Req'd
Duplexer, Receiver - AAI	464032-150	1
Isolator, Radio Frequency Reflection	464079-150	4
Amplifier, Oscillator Control - AAI	464108-150	2
Waveguide Assembly - Interrogator	464116-150	1
Duplexer, Transmitter - Interrogator	464132-150-	1
Switch, Waveguide - Interrogator	464152-150	1
Transmitter, Radio - AAI	464159-150	2
Duplexer, Transmitter - Transponder	464232-150	1
Switch, Waveguide - Transponder	464252-150	1
Attenuator-Detector, Radar Signal	464279-150	2
Coupler, Directional - Interrogator	464284-150	1
Synchronizer, Electrical AAI	464303-150	1
Waveguide Assembly - Radar - AAI	464316-150	1
Cavity, Tuned - AAI	464332-150	1
Amplifier - Synchronizer - Transponder	464333-150	1
Coupler, Directional - Transponder	464384-150	1
Amplifier - Frequency Converter - Interrogator	464566-150	1
Amplifier - Synchronizer - Interrogator	464567-150	1
Amplifier - Frequency Converter - Transponder	464666-150	1

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COMMUNICATION & NAVIGATION SUB-SYSTEM:

Sub-System Components	Unit # (Or Equiv.)	# Req'd	
Amplifier, Electronic Control, ADF, Audio	464606-150	1	
Antenna - ADF	464117-150	1	
Tuner, RF - UHF	464225-150	1	
Receiver - Interrogator, TACAN	476129-150	1	Available if required
Modulator - Coder, TACAN	464229-151	1	Available if required
Transmitter, Range, TACAN	464329-150	1	Available if required
Transmitter, Bearing, TACAN	464429-150	1	Available if required
Transmitter, Radio - Communication, UHF	464059-151	1	
Receiver, Radio - AM Data Link	464067-150	1	
Receiver, Radio - Communication UHF	464167-150	1	
Power Supply - Communication	464392-151	1	

(For ARN-6 and J4 Compass, see P. 12)

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FLIGHT SENSING SUB-SYSTEM:

STABILIZATION GROUP:

Sub-System Components	Unit # (Or Equiv)	# Req'd
Amplifier, Electronic Control - Integrator	464009-150	1
Amplifier, Electronic Control - Roll and Pitch	464109-150	1
Demodulator, Channel	464209-150	1
Amplifier, Electronic Control - Azimuth	464309-150	1
Junction Box - Latitude Counter	476409-150	1
Stable Element	476289-150	1
Test Set, Communication and Navigation Sub-system	464396-150	1
AIR DATA GROUP:		
Air Data Computer	464646-151	1
Converter, Signal Data - Altitude rate	464320-150	1
Converter, Signal Data - Air Data	464420-150	1
Compensator, Air Data Static Pressure and Angle of Attack	464721-150	1
AFCS		
Amplifier Computer Aerodynamic	464021-150	1
Amplifier Computer Control Surface Command	464121-150	1
Amplifier Computer Attitude Memory	464321-150	1
No Title Available	xxx421-150	1
	xxx221-150	1
	xxx621-150	1

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COCKPIT SUB-SYSTEM

Sub-System Components	Unit # (or equiv)	# Req'd
Armament Control Panel	X470005-100	1
Control, Intercommunications Set	472005-150	2
Control Panel, Transfer Relay	X470105-100	2
Control, Frequency Selector - Communications	464505-151	2
Filter, Light, Cathode Ray Tube	464025-150	2
Control, Radar Set	464305-150	1
Control, Frequency Selector GCI Channel	464605-150	1
Control, Power System	464905-150	1
Visor, Cathode Ray Tube	464125-150	2
Control, Antenna Hand	X470019-100	1
Annunciator, Computer Mode	464034-150	1
Control, Frequency Selector Sub-Carrier Channel	464355-150	1
Control, Indicator - R.O.	468355-150	1
Control, Radar Set - Identification	464555-150	1
Control, Coder/Decoder	464655-150	1
Control, Radar Set - Az Scan and Horizon Adjust	464855-150	1
Relay Assy, Control Transfer - Group Three A	472764-150	1
Control, Indicator	435-71-0001	1
Indicator, Flight Command Search and Attack	X470080-100	2
Indicator, Horizontal Situation - Tactical	X470180-100	1
Indicator Assy - Command and Target Altitude	464980-150	1
Panel, Self Test AWCS	464796-150	1

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ARMAMENT AUXILIARY SUB-SYSTEM:

Sub-System Components	Unit # (or equiv)	# Req'd
Power Control Unit, Gyro-Car	464008-150	1
Motor Generator - 1600 cps	476726-150	1
Control, Channel, Missile AFC	476043-150	1
Launcher Rocket, Airborne - Model LE-6	464054-151	4
Relay Assembly - Armament Control, No. 1	X470264-100	1
Relay Assembly - Parameter Setting	476364-150	1
Relay Assembly - Mode Selection	X470464-100	1
Relay Assembly - Armament Control No. 2	X470664-100	1
Amp., Electronic Control - Missile Antenna	476266-150	1
Amp., Electronic Control - Missile Antenna Test	476366-150	1
Power Supply - Control, Rocket	464087-150	1
Relay Assembly - Armament Test	X470496-150	1
Panel, Test, Electrical - Armament	X470596-100	
Master Program Sequence	X470010-100	1

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POWER SUB-SYSTEM:

Sub-System Components	Unit # (or equiv)	# Req'd
Power Distribution No. 1	X470018-100	1
Power Distribution No. 2	X470010-100	1
Power Distribution No. 3	X470218-100	1
Power Supply - Plus and Minus 50 Volt DC	X470126-100	1
Power Supply - Minus 140 Volts DC	X470326-100	1
Power Supply - Minus 150 Volts DC	476526-150	1
Power Supply - Plus 300 Volts DC	476626-150	1
Power Supply, AC-115V, 1600 cps	X470826-100	1
Power Supply - Ref. 115/58V 1600 cps	X470491-100	1
Power Supply - Minus 250 Volts DC	X470192-100	1
Power Supply - Ref. 100 VDC, 140 VDC	X470292-100	1

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AVRO SUPPLIED EQUIPMENT:

COCKPITS:

Instruments:

Indicator, Airspeed, Mach Safe Speed	Aerno # 60-6306	1
Indicator, Altitude, Vertical Speed	60-6307	1
Indicator, Horizontal Situation	60-6308	2
Indicator, Attitude Director	60-6310	1
Computer, Flight Director	60-6309	1
Indicator, Altimeter (Standby)	60-6301	1
Indicator, Airspeed (Standby)	60-6303	1
Indicator, Alpha		1
Indicator, Beta		1
Indicator, G-Trim		1
Indicator, Cabin Pressure		1
Indicator, Oxygen quantity		2
Clock		2
Fuel quantity		2
Total fuel remaining		1
Engine Performance		2
Control Surface Position		1
UHF Channel Indicator		2
Landing Gear Indicator		1
True Air Speed		1

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AVRO SUPPLIED EQUIPMENT Continued/

Panels etc:

Master warning Red	1
Master Warning Amber	1
Obs. Bail Out Green	1
Obs. Bail Out Red	1
Landing Gear Selector Panel	1
Pilots Canopy Switch Panel	1
Throttle Box	1
Fire and Fuel Panel	1
Damper Function Selector Panel	1
Damper Circuit Breaker Panel	1
Test Switch Panel	1
Heading Selector Switch	1
Master Warning Panel	1
Master Electrical Panel	1
Aerobatic Switch Panel	1
Oxygen & Switch Panel	1
Air Conditioning Panel	1
Pilots Cockpit Lighting Panel	1
Auxiliary Switch Panel	1
Obs. Canopy Switch Panel	1
Obs. Cockpit Lighting Panel	1
Muting Foot Switch	1
Press to Talk Foot Switch	1

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SECTION 4

Testing - MA-1-C System and Falcon/MB-1 Weapon pack.

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GROUND AND FLIGHT TESTING

To support the design and installation of the MA-1C system and MB-1/Falcon armaments, the following testing is required:-

1.0 GROUND TESTING

1.1 Tunnel testing of weapon launching and carriage

1.2 MB-1 installation including:

1.2.1 Functional testing of doors, mechanisms, hydraulic system, electrical control and sequencing.

1.2.2 Limited structural testing of launcher rack installation.

1.3 Falcon installation

1.3.1 Functional testing of doors, launcher lowering mechanism, hydraulic system, electrical control and sequencing.

1.3.2 Ground Firing (Minimum to clear pack for flight)

1.4 Pack Fuel System

Additional fuel system and ad.hoc tank structure testing.

1.5 MA-1C Installation

Rig testing of detail air conditioning distribution changes. Miscellaneous power system testing and compatability checks.

2.0 FLIGHT TESTING

2.1 Armament

2.1.1 Flight testing of armament installation on Arrow 1 aircraft for:

(a) mechanical and system performance

(b) Launch and separation testing and evaluation

(c) Blast effects

2.1.2 Flight testing on Arrow 2 aircraft in conjunction with the Fire Control system to establish overall compatability and limited evaluation as a weapon system.

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2.2 MA-1C System

2.2.1 Flight testing on Arrow 1 # 25203 to establish basic MA-1C/Arrow compatability.

The Arrow 1 airframe provides a useful vehicle for this program and will permit maximum flying time.

2.2.2 Flight testing on Arrow 2 aircraft for Arrow 2/MA-1C development and compatability, including:

(a) Environmental testing

(b) Serviceability

(c) System compatability - cooling power supplies etc.

(d) MA-1C system assessment including Radar range on search and lock. Displays, navigation and communication, AFCS.

(e) Antennae/systems evaluation.

This testing will lead to a joint RCAF/AVRO test/evaluation program of the aircraft as an operational weapon system.

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SECTION 5

Flight Test - Instrumentation

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FLIGHT TEST INSTRUMENTATION

Aircraft	Installed	Approximate No. of measurements Recordable at one time on:- Oscillographs	Photo Panel	Data Tape	Telemetry	Cameras (For strike and/or launch observations, except as noted).
25201	450	2 x 30	NIL	NIL	12	For compass checks only
25202	450	30	NIL	85	50	No
NOTE: Instrumentation Packs for Aircraft 25201 and 25202 are interchangeable.						
25203	300	50 (*1)	NIL	NIL	NIL	Yes (*4)
25204	150	30	35	NIL	NIL	For U/C testing only.
25205	65	2 x 30	NIL	NIL	NIL	Yes
25206	225	2 x 30	40	NIL	12	No
25207	175	2 x 30	NIL	150	9	No
25208	230	2 x 30	NIL	NIL	50	For Drop Tank tests only.
25209	50 (Provision only)	30 (Provision only)	NIL	NIL	NIL	No
25210 to 25213	250 (*2)	50 (*1)	NIL	NIL	NIL	Yes (*4)
25214	250 (*2)	Provision only	NIL	NIL	NIL	Provision only.
25215	295 (*3)	30	35	NIL	NIL	No
25216 to 25220	250 (*2)	50 (*1)	NIL	NIL	NIL	Yes (*4)

Revised 12/11/58

AD-53 ISSUE 2 PROGRAM REDUCTIONS UNCLASSIFIED

List of items of work previously planned but now deleted or reduced in scope (excluding reductions directly attributable to Astra-Sparrow cancellation).

1.2.1	Arrow Weapon System model specification - deleted.
1.3	Assistance to RCAF with requirements specifications - now limited to WSC 1-2.
2.3.1) 3.3.1)	Airborne instrumentation reduced approximately 33% due to reduction in test program aircraft from 37 to 20.
2.3.2) 3.3.2) 10.6)	Maintenance spares allowance reduced from 15% to 12% of air-frame and GSE cost on basis of actual CF-100 experience.
3.2.2) 3.2.4)	Tool maintenance and tool improvement reduced approximately 30% on the basis of estimated requirements of the new schedule.
4.1.5	Development of simulation aids for weapon system studies - deleted.
4.1.7	Acoustic fatigue test program - reduced program included in airframe design.
4.1.8	Thermal effects test program - reduced program included in airframe design.
4.2.5	Sled testing escape system - deleted.
4.4.3	Maintenance and operation of chase aircraft - cost of reconversion deleted; will be covered by R & O contracts for CF-100 and Sabre.
4.4.3	CF-100 test vehicles for Arrow program - cost of reconversion deleted; will be covered by R & O contracts for CF-100 and Sabre.
6.6	Program Planning Report - deleted.
6.7	Quarterly Technical Report - deleted.
6.14	Airframe EO's - adoption of reduced-cost format.
6.15	Equipment EO's - reduced-cost format and elimination of EO's available from existing sources.
6.18	Co-ordination of weapon system EO coverage - deleted.
6.19	Data and assistance for OFTT - deleted.

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7.10	Weapon system mathematical model - deleted.
7.11	Extension of 7.10 re growth potential and tactics - deleted.
7.13	Weapon system air base requirement studies - deleted.
7.14.3	Personnel requirement data study - deleted.
7.15	Study and analysis of Associate Contractor technical progress reports - deleted.
7.20	OFTT study - deleted.
8.5	Support to Arrow Weapon System demonstration - deleted.
9.2) 9.3)	Reduction of anticipated changes.
10.1) 10.7)	Deletion of Ground Equipment Trainer.
10.10	GSE co-ordination services - deleted.
10.12	Assistance to RCAF in preparation of GSE procurement specs - deleted.
12.5	Co-ordination of Associate Contractors' statements of work - deleted.
12.10	Analysis of Associate Contractors' data control systems - deleted.
11.4) 12.21)	Mobile repair and maintenance party costs and field service representative costs reduced on basis of two RCAF stations instead of four.

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SUMMARY

Avro requirements for training on the electronic and damper systems, and Avro and Orenda requirements for cross-training, as defined herein, have been reviewed by the AWSC Department.

The varying requirements have been reduced to a manageable program, by defining three levels of training: (a) familiarization (b) basic and (c) complete. The approximate dates for completion of training and, where possible, the length of courses have been detailed.

The proposed contractual arrangements for effecting the program are included.

This report supersedes AWSCC Report No. 5.

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1. INTRODUCTION

1.1 Requirement for Formal Training

In order to satisfactorily carry out the Arrow engineering, manufacture and test program defined by AD-53 Issue 2, Statement of Work, Revised Arrow Program, it is necessary that engineers and technicians employed by Avro Aircraft Limited be trained on the theory and operation of equipment manufactured by Associate Contractors and sub-contractors. Four of the sub-systems, the Iroquois engine, the MA-1C integrated electronic system, the Falcon missile, and the YG-339B damper system, are of sufficient complexity to make formal training courses mandatory.

1.2 Training on Electronic, Missile and Damper Systems

Avro is responsible (with technical assistance from Hughes Aircraft Company) for compatibility of airframe and electronics, and for pre-installation testing, installation, primary function, calibration, and repairs (to the first and second line maintenance level) of the MA-1C electronic system. Experience with the MG-2 system has shown that a formal training course including practical work, or a lecture course followed by on-the-job training, is essential to enable personnel to carry out their duties in an efficient manner. The number of people required is based on MG-2 experience with a factor to allow for the added complexity of the MA-1C system.

Similar requirements exist for training on the Falcon missile.

In the case of the damper system, Avro responsibilities are the same as in the MA-1C system, but the assistance provided by the sub-contractor will be on an as-required basis rather than full time.

1.3 Avro-Orenda Cross-Training

Avro is responsible for installation, run-up, and first line maintenance and removal of the Iroquois in the Arrow. Orenda is responsible for second and higher line maintenance of all Iroquois engines up to RCAF acceptance of the aircraft, including build-up of Orenda-supplied accessories and all adjustment and fault rectification requiring a check-out and run-up facility. In order to accomplish these tasks efficiently, and particularly to ensure that no unnecessary removals of engines take place, it is necessary that a limited number of both Avro and Orenda personnel receive training on the related systems of both the airframe and the engine.

In addition, Orenda aircrew must receive conversion training for the Arrow in order to carry out flight operations on aircraft allocated to Iroquois test programs. Training of Avro personnel on the engine, and Orenda personnel on the airframe, will be referred to hereafter as "contractor cross-training".

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1.4 Scope of this Report

This report deals with contractor cross-training and training of Avro personnel on the electronic, missile and damper systems, but excludes training of Avro and Orenda personnel on their own products.

2. REQUIREMENTS

2.1 Preliminary Estimate of Program

In order to form an estimate of the nature of the training required, and the number of people to be trained, Avro and Orenda were asked to submit requirements for training under the headings of type of training, required date of completion, and the number of people involved. Replies received indicated that 52 different training courses would be required, extending from the present time to December 1960. This is obviously impracticable, but the requirements, exactly as received, are summarized, for reference only, in Table 1.

2.2 Program Planning

To reduce the information contained in Table 1 to a manageable program, three arbitrary levels of training were selected as follows:

2.2.1 Familiarization

Short courses for those (usually senior personnel) who need to have an appreciation of the problems involved, but who will not be engaged at any time in actual operations.

2.2.2 Basic Course

More detailed than the familiarization courses, basic courses are directed at those who require a background in theory, operation and maintenance, but who will not be engaged directly in operation or testing. These courses, supplemented by manuals or EO's, should enable an experienced engineer or technician to supervise the handling of problems as they arise.

2.2.3 Complete Course

These courses are detailed and are designed to train engineers and technicians who are to be engaged in actual testing, calibration and trouble-shooting.

The information in Table 1 has been re-grouped into these three general classifications as shown in Table 2. Dates for conducting these courses are included, together with the length of course where this information is available.

The organization of trained personnel to support the electronics, missile, and damper systems in aircraft allocated to test programs at Avro, and aircraft being prepared for delivery to RCAF bases for

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test programs or squadron service, is shown in Table 3. The peak load is 13 aircraft; the organization shown is marginally adequate to handle this load.

2.3 Location of Schools

Avro and Orenda will conduct courses on the airframe and engine respectively at their Malton facilities. Initial training on the integrated electronic system and the Falcon missile will be given by Hughes Aircraft Company at Culver City, under sub-contract to Avro. Training on the YG-339B damper will be given by Honeywell Controls Limited at its Toronto facility, similarly under sub-contract.

During 1960, it may be possible to send a limited number of contractor personnel to the RCAF training school at Camp Borden.

3. CONTRACTUAL COVERAGE

3.1 The following items are covered by paragraph 12.4 of AD-53 Issue 2 Statement of Work, Revised Arrow Program:

(a) Procurement of training courses and instructors under sub-contract from Hughes Aircraft Company and Honeywell Controls Limited.

(b) Labor costs of Avro personnel attending courses on the engine, electronic, and damper systems.

3.2 The preparation and presentation of airframe courses for Orenda personnel are covered in paragraph 12.19(a) of AD-53 Issue 2.

3.3 The co-ordination of contractor cross-training is covered in paragraph 12.19(a) of AD-53 Issue 2.

3.4 The preparation and presentation of engine courses for Avro personnel is covered in Orenda Engines Limited Statement of Work.

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TABLE 1 (CONT'D)

(a) Cont'd

TYPE OF COURSE	NUMBER OF AVRO PERSONNEL				
	FLIGHT OP'NS.	MANUF'G	ENG.	SALES & SERVICE	QUALITY CONTROL
(i) MA-1C Electronic System (Cont'd)					
Radar Mechanics		(Apr. 59 (5 (Sept 59 (10 (Feb. 60 (19 (Aug. 60 16			
Supervision, C & N		(Sept 59 (1 (Feb. 60 (1			
Radio Mechanics		(Sept 59 (6 (Feb. 60 (6 (Aug. 60 (6			
Inspectors					(Mar. 59 (3 (Sept 59 (4 (Feb. 60 (4 (Aug. 60 (3

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TABLE 2

(a) Avro Training Requirements Summary

TYPE OF COURSE	LEVEL (see para 2.2)	DURATION (weeks) (approx.)	COMPLETION DATE	NUMBER OF TRAINEES
MA-1C Integrated Electronic System				
Briefing	1	1	Mar. 59	14
Basic course	2	10	Sept 59	2
	2	10	Aug. 60	2
Complete course	3	20	* Apr. 59	14
	3	20	Sept 59	40
	3	20	Feb. 60	32
	3	20	Aug. 60	26
				130
Falcon Missile				
Briefing	1	1	Sept 59	8
Basic course	2	Not known	Sept 59	2
			Aug. 60	2
Complete course	3	11	Mar. 59	1
			* Nov. 59	16
				29
MG-339B Damper				
Briefing	1	1	Mar. 59	12
Basic course	2	4	Dec. 59	1
	2	4	Dec. 60	2
Complete course	3	8	Nov. 58	11
	3	8	Mar. 59	9
	3	8	Sept 59	11
	3	8	Feb. 60	11
	3	8	Aug. 60	8
				65

* These courses given by HAC at Culver City; all other MA-1C and Falcon courses are expected to be given at Avro by HAC instructor.

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TABLE 2 (CONT'D)

(c) Recapitulation

TYPE OF COURSE	NUMBER OF TRAINEES	
	AVRO	ORENDA
MA-1C integrated electronic system	130	
Falcon missile	29	
YG-339B damper	65	
Airframe		15
Iroquois engine	61	
	285	15

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TABLE 3

FULLY TRAINED PRODUCTION PERSONNEL REQUIRED TO SUPPORT ELECTRONIC, MISSILE AND DAMPER SYSTEMS

The following is required to support a peak load of 13 aircraft. The actual distribution of people will change from day to day to suit requirements.

First Shift

MA-1C Electronic System:-	
Bench Test Positions:	
Supervision	1
Radar and computer mechanics	6
C & N mechanics	2
Hanger Floor:	
Supervision	3
Radar and computer mechanics	19
C & N mechanics	7
Falcon Missile:-	
Supervision	1
Electrical and electronic mechanics	3
Damper:-	
Bench Test Positions:	
Mechanics	2
Hangar Floor:	
Supervision	1
Mechanics	8
	53

Second Shift

Same as first shift	53
	106

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AVRO AIRCRAFT LIMITED

MALTON – ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

SECRET

AIRCRAFT: ARROW 2

REPORT NO: Periodic Performance Report No. 15

FILE NO: 72/PERF/36

NO. OF SHEETS 49

TITLE:

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PERFORMANCE OF THE ARROW 2

PREPARED BY Performance Group R.G. Rose DATE Nov. 1958

RECOMMENDED FOR APPROVAL [signature] DATE Nov/58

APPROVED [signature] DATE Nov/58

APPROVED FOR RELEASE [signature] DATE Nov/58

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ARROW PERIODIC PERFORMANCE REPORT 15

PERFORMANCE OF THE ARROW 2

(C.G. at 29.5% MAC)

SUMMARY

The performance data given in this report are based on the drag data given in Avro Report 71-2/Aero Data/17 (Revised Arrow drag based on preliminary flight test results) and propulsion data given in 72/Int. Aero/33 (Developed Iroquois Series 2 with 8050 maximum N_H r.p.m. and developed afterburner). They represent the best estimate of the ultimate performance of the Arrow 2 as at present envisaged.

The main differences between this report and Periodic Performance Report Number 14 are:-

1. Revised drag data.
2. Revised Engine data.
3. Change of fire control system and missile load to Hughes MA-1, with MB-1 and GAR-3/4 missiles.
4. A decrease in operational weight empty of 758 lb. mainly due to (3).

The loading and performance data, flight envelopes, and mission profiles are given in Figures 1 to 9(b) and in Tables 1 to 7 inclusive.

The Thermodynamic envelope is based on a recovery factor of 0.90. The Flight envelope limitations are based on strength and control considerations only, and do not necessarily represent the steady performance capabilities of the aircraft.

The Operational Weight Empty used in this report is considered to be conservative and approximate only, as is the internal fuel load in the weapon pack. The internal fuel has been assumed to be the 19,433 lb. basic plus 2,180 lb. in the weapon pack. To allow for variations of O.W.E. and weapon pack fuel, the effects of 1,000 lb. reduction in operational weight empty, and an extra 1,000 lb. of fuel in the missile pack, on the combat radii of action and ferry range are quoted in the following table:-

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TABLE 1 - LOADING AND PERFORMANCE

UNDER ICAO STANDARD ATMOSPHERE CONDITIONS

(Clean aircraft, i.e. no ventral tank, unless otherwise stated)

WEIGHT

	Operational weight empty	lb.	45,892
	Maximum useable internal fuel	lb.	21,613
	Gross take-off weight (maximum internal fuel)	lb.	67,505
	Combat weight (1/2 max. internal fuel weight)	lb.	56,699
	Maximum external fuel and tank (500 gallons at 7.8 lb/gall. + drop tank)	lb.	4,242
	Maximum gross take-off weight (Combat mission)	lb.	71,747
†	Maximum gross take-off weight (Ferry mission)	lb.	70,411
	Normal design landing gross weight	lb.	49,958
	Maximum landing gross weight (Combat Mission)	lb.	67,505
	Wing loading at gross take-off weight	lb/sq. ft.	55.2
	Power loading at gross take-off weight	lb/lb thrust	1.55

SPEED

True airspeed in level flight at combat weight

Sea Level	(i)	Maximum thrust, A/B lit	Kts.	700 ★
	(ii)	Maximum thrust, A/B unlit	Kts.	675
50,000 ft.	(i)	Maximum thrust, A/B lit	Kts.	1,147 ★

★ Placard speed

† Maximum gross take-off weight (Combat Mission) less 1336 lb. missiles

CEILING

Ceiling at combat weight, rate of climb 500 ft/min. with max. thrust at optimum Mach number (1.8 M) A/B Lit		ft.	61,050

RATE OF CLIMB

Steady state rate of climb at combat weight

Sea Level	(i)	Maximum thrust, A/B lit, at 0.92M	ft/min.	44,600
	(ii)	Maximum thrust, A/B unlit at 527 Kts TAS	ft/min.	18,600
50,000 ft.	(i)	Maximum thrust, A/B lit at 1.8 M	ft/min.	10,330

TIME TO HEIGHT

Time to reach 50,000 ft. and 1.5 M from engine start at gross take-off weight, max. thrust A/B lit	min.	4.8

MANOEUVRABILITY

Load factor at combat weight

1.	Maximum thrust A/B lit 1.5 M at 50,000 ft.	1.62
2.	Maximum thrust A/B lit 1.8 M at 50,000 ft.	1.77

TAKE-OFF DISTANCE

Take-off distance over 50 ft. obstacle at sea level at gross take-off weight

1.	Maximum thrust A/B lit , standard day (+15°C)	ft.	4,000
2.	Maximum thrust A/B unlit, standard day(+ 15°C)	ft.	5,070
3.	Maximum thrust A/B lit, hot day (+38°C)	ft.	4,870

LANDING DISTANCE

Landing distance over 50 ft. obstacle at sea level at normal design landing gross weight	ft.	5,260

STALLING SPEED

True stalling speed in landing configuration at combat weight at sea level	Kts.	117

MISSIONS

Combat radius of action, see mission profile for detail breakdown.

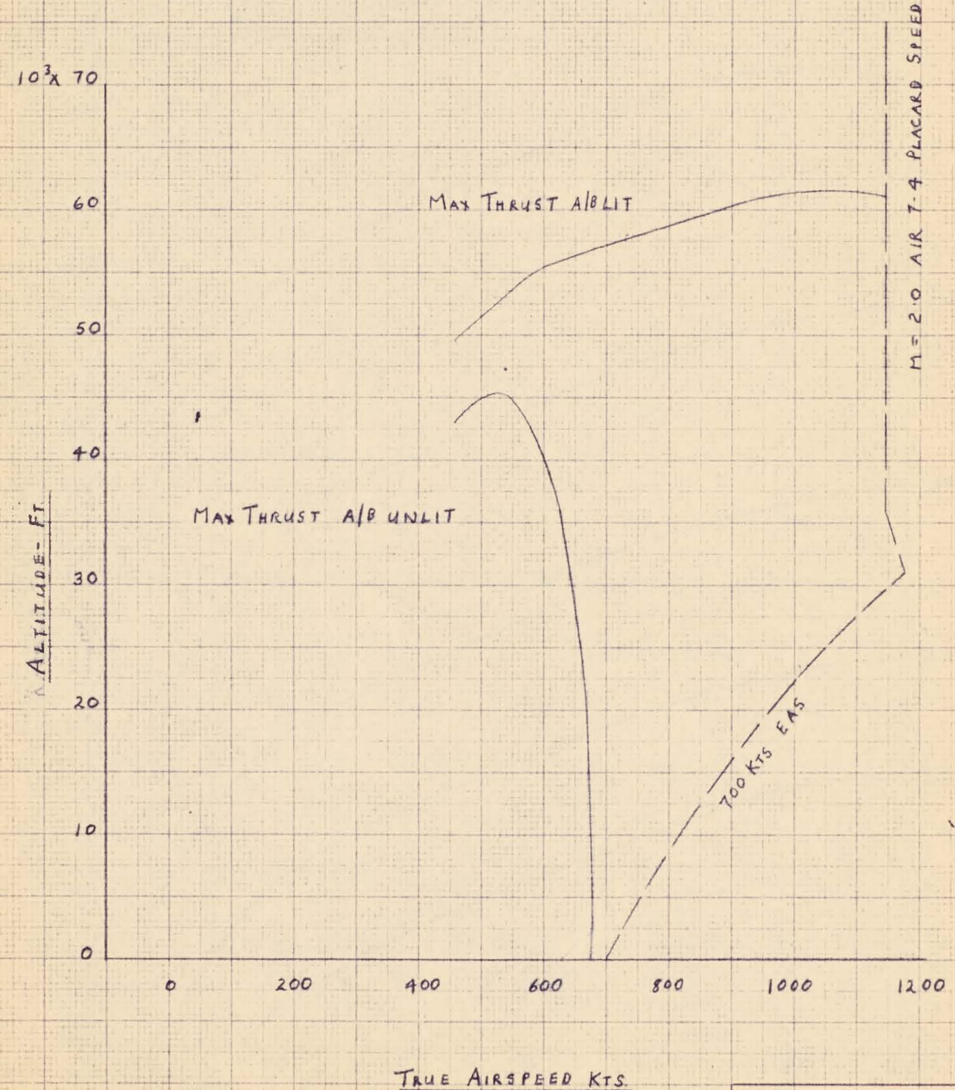
1.	Subsonic high altitude mission - subsonic combat		n.m.	589
2.	Subsonic high altitude mission - supersonic combat		n.m.	506
3.	Supersonic (1.5 M) high altitude mission - supersonic (1.5 M) combat		n.m.	358
3A.	Supersonic (1.8 M) high altitude mission - supersonic (1.8 M) combat.		n.m.	338
4.	Combat air patrol - supersonic combat		n.m.	623
5.	Subsonic low level mission (10,000 ft.) - subsonic combat		n.m.	396
6.	Ferry Mission (no armament) ventral tank carried throughout	Range	n.m.	1,500

ARROW 2

IROQUOIS SERIES 2 ENGINES

MAX LEVEL SPEED AT COMBAT WEIGHT (56,699 LB)

UNCLASSIFIED



DRAG -	71-2/AERO DATA/17
PROPULSION -	72/INT. AERO/33

FIG 1

UNCLASSIFIED

ARROW 2

TIME TO HEIGHT IROQUOIS SERIES 2 ENGINES

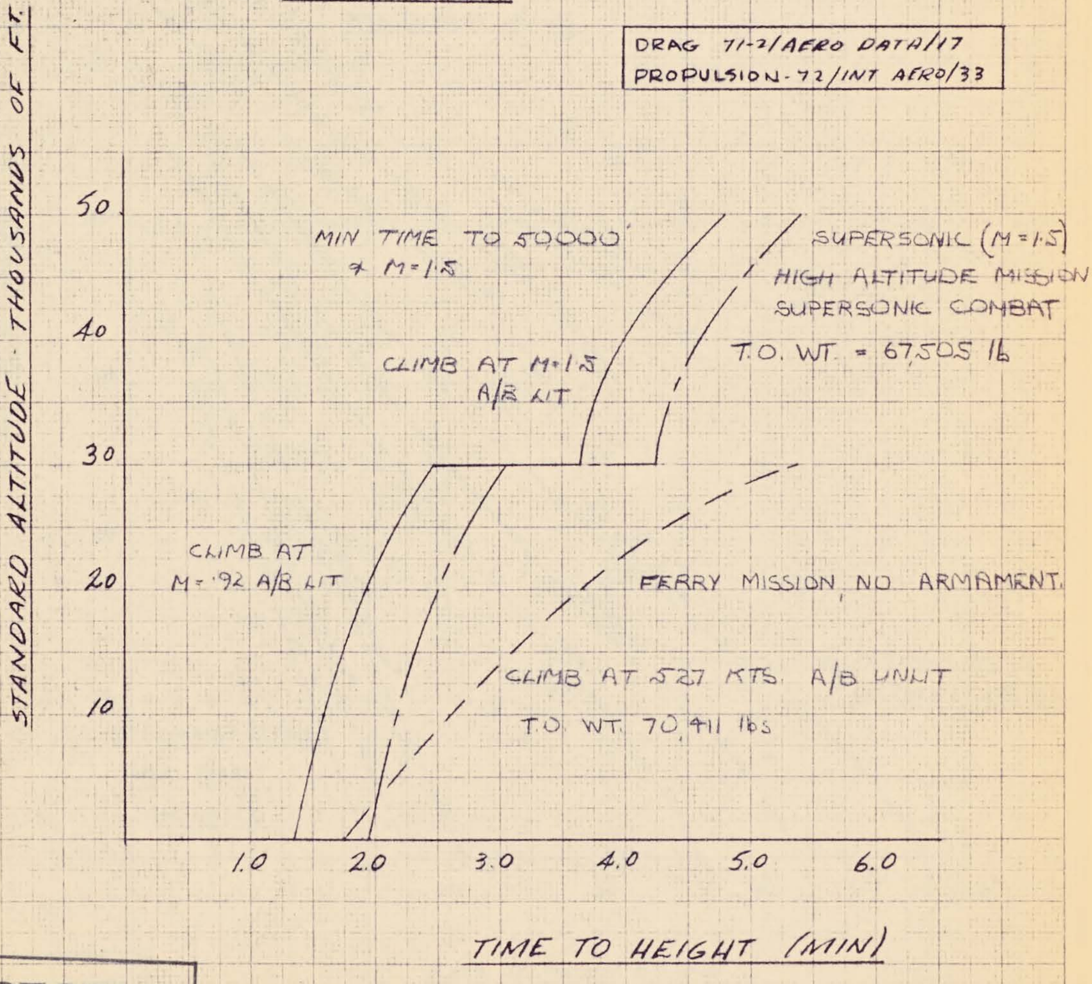
– – – – FERRY MISSION VENTRAL TANK CARRIED THROUGHOUT NO ARMAMENT AFTERBURNER UNLIT

——— MINIMUM TIME TO HEIGHT + 1.5M AFTERBURNER LIT THROUGHOUT FLIGHT

— - — SUPERSONIC HIGH ALTITUDE MISSION - SUPERSONIC COMBAT - AFTERBURNER LIT AT START OF M=.92 CLIMB

NOTE - ½ MINUTE ALLOWED FROM ENGINE START TO MAX. THRUST

DRAG 71-2/AERO DATA/17
PROPULSION - 72/INT AERO/33



SECRET

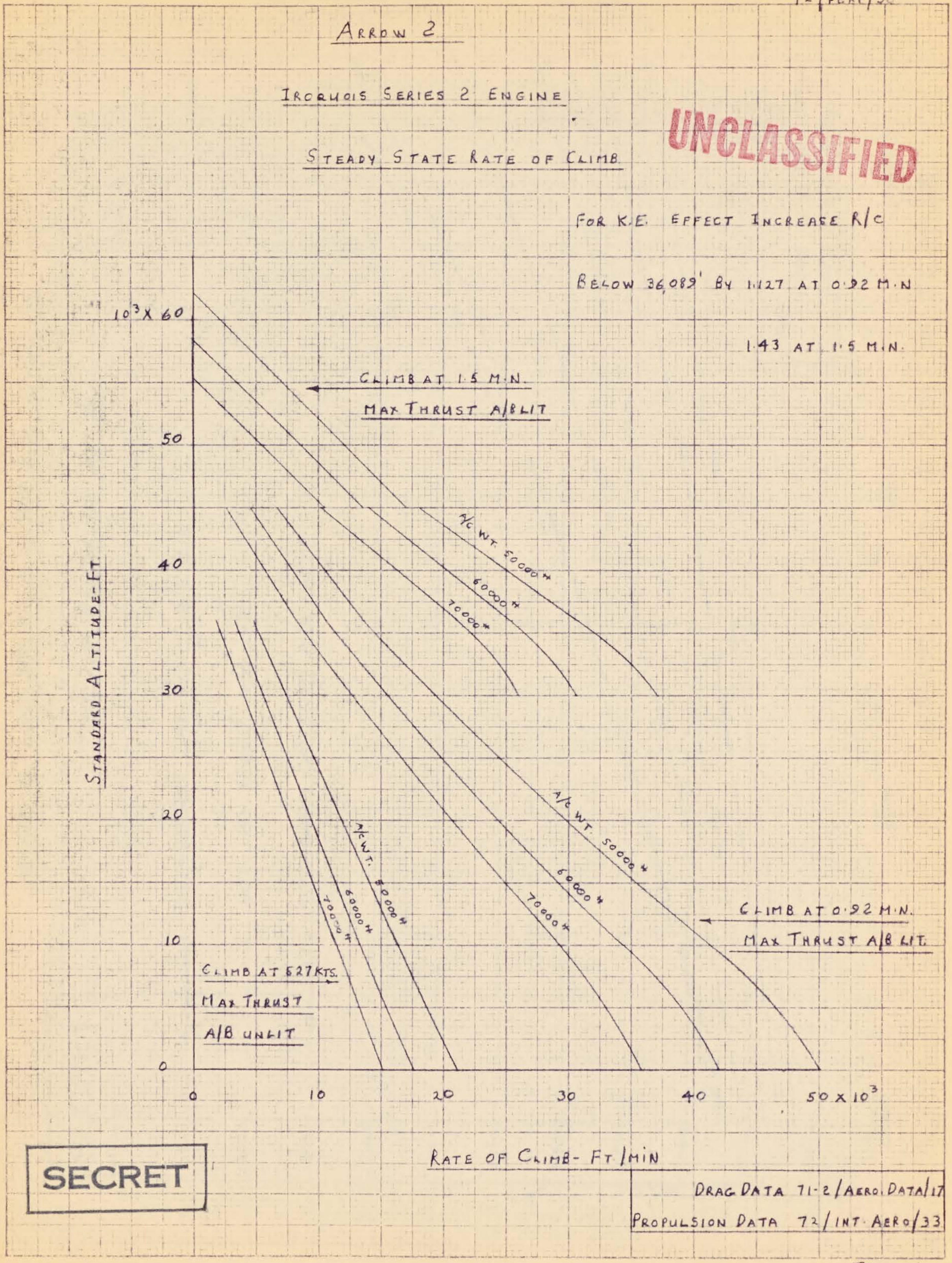
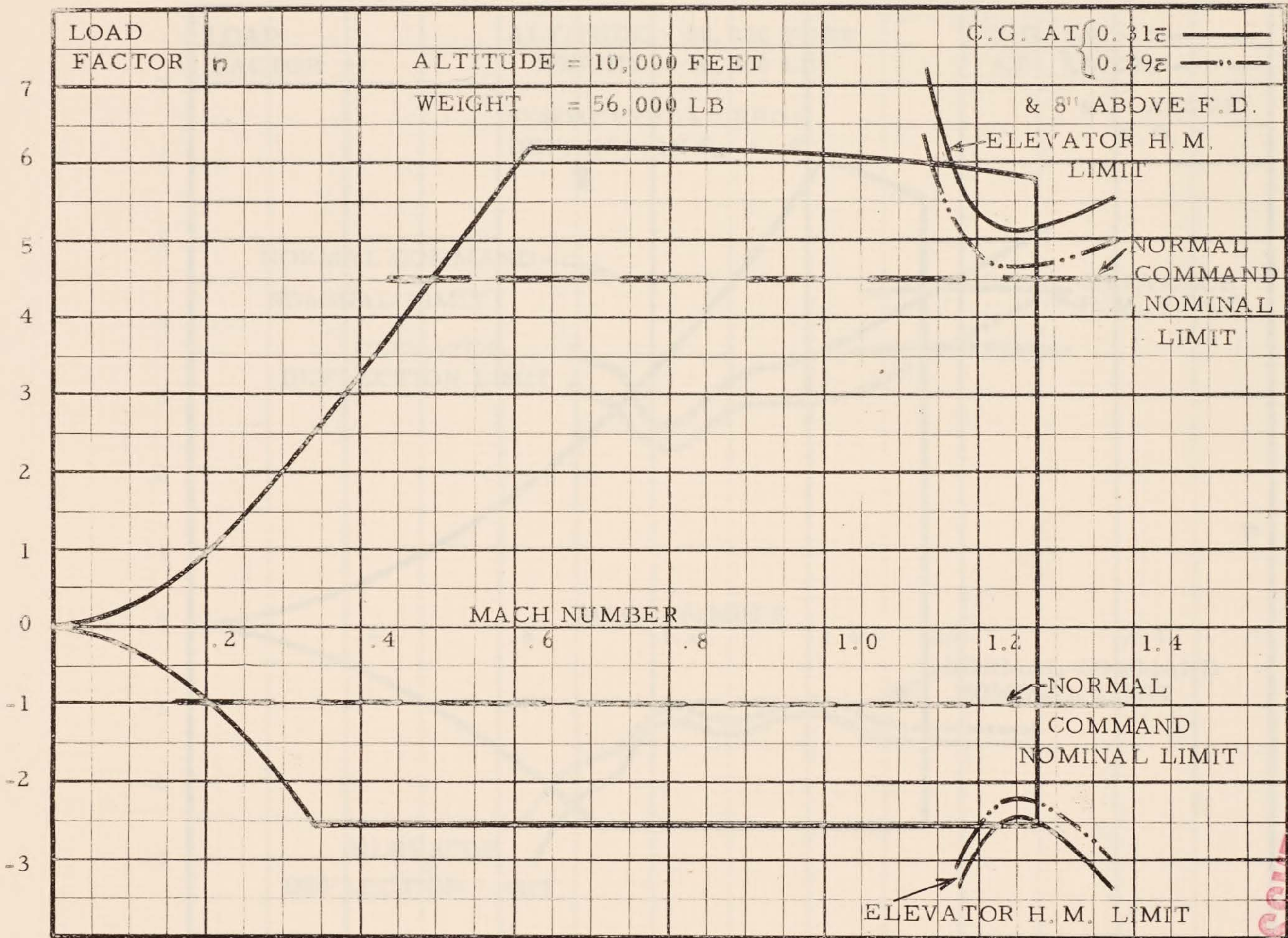

ARROW 2
IROQUOIS SERIES 2 ENGINE
STEADY STATE RATE OF CLIMB
UNCLASSIFIED
FOR K.E. EFFECT INCREASE R/C
BELOW 36,089' BY 1.127 AT 0.92 M.N
1.43 AT 1.5 M.N.
CLIMB AT 1.5 M.N.
MAX THRUST A/B LIT
A/C WT. 50000#
60000#
70000#
CLIMB AT 0.92 M.N.
MAX THRUST A/B LIT.
CLIMB AT 527 KTS.
MAX THRUST
A/B UNLIT
STANDARD ALTITUDE-FT.
10^3 X 60
50
40
30
20
10
0
0
10
20
30
40
50 X 10^3
RATE OF CLIMB- FT/MIN
SECRET
DRAG DATA 71-2/AERO. DATA/17
PROPULSION DATA 72/INT. AERO/33

FIG. 4

FORM 1749 A-2

ARROW 2 FLIGHT ENVELOPE LIMITATIONS

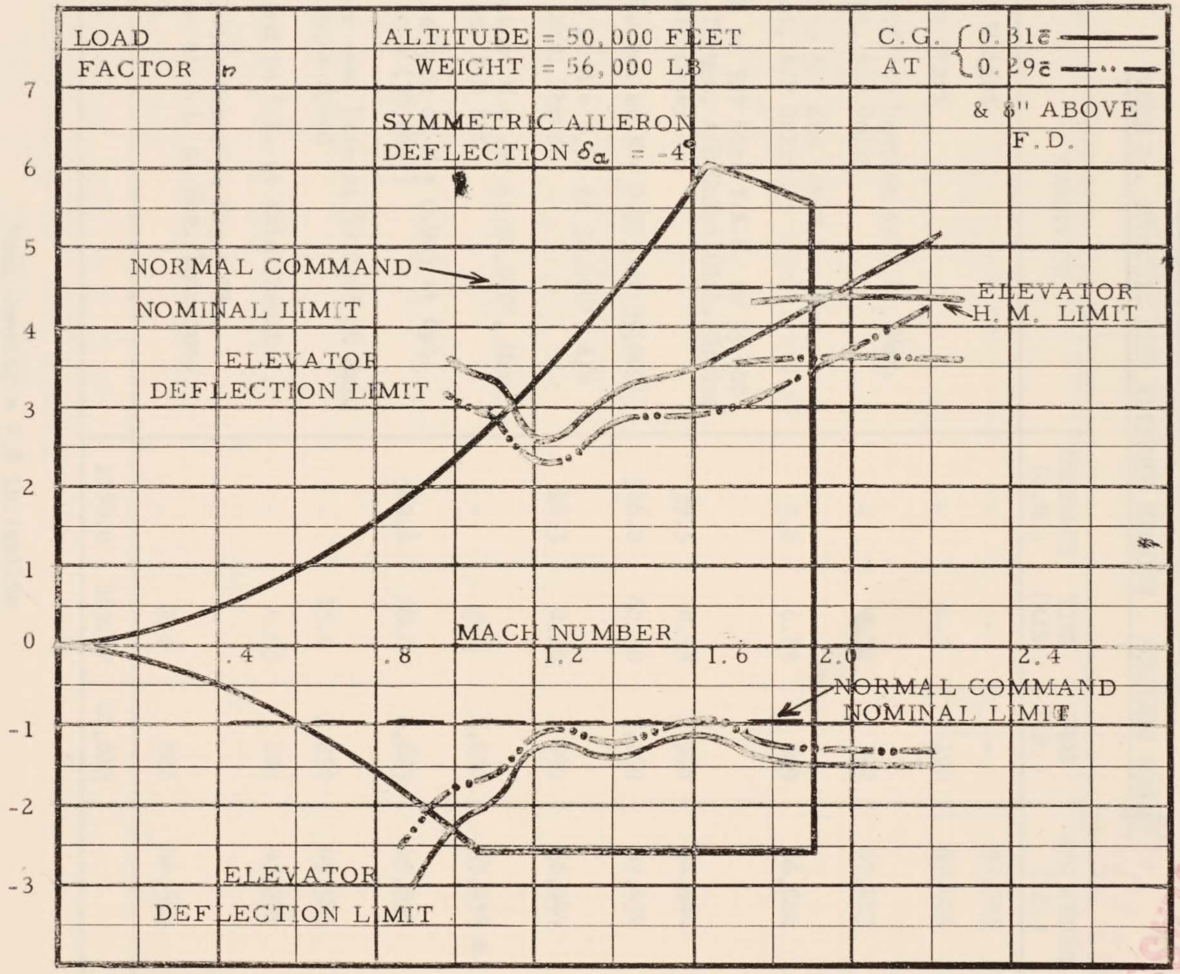


All load factors except Normal Command Nominal Limit can be factored for weight change

i.e. $n_{NEW} = n_{Curve} \times \frac{56,000}{W_{NEW}}$

FIG. 9(a)

ARROW 2 FLIGHT ENVELOPE LIMITATIONS



All load factors except Normal Command Nominal Limit can be factored for weight change

i.e. $n_{NEW} = n_{Curve} \times \frac{56,000}{W_{NEW}}$

FIG. 9(b)

UNCLASSIFIED

ARROW 2 WITH IROQUOIS SERIES 2 ENGINES

TABLE 3 SUBSONIC HIGH ALTITUDE MISSION - SUPERSONIC COMBAT (1.5 M)

UNCLASSIFIED

CONDITION	DIST. N.M.	TIME MINS	FUEL LB.	A/C WT. LB.
Start weight	-	-	-	67,505
Engine start	-	0.5	100	67,405
Take-off to unstick at sea level max. thrust A/B unlit	-	0.32	192	67,213
Acc. to 527 kts. at sea level max. thrust A/B unlit	5.0	0.85	609	66,604
Climb at 527 Kts. TAS to 35,000' max. thrust A/B unlit (opt. cruise-out alt.)	39.5	4.55	1910	64,694
Cruise-out at M = 0.905 at 35,000'	435.4	50.0	6078	58,616
Acc. to 1.5M at 35,000' max. thrust A/B lit	14.1	1.22	1135	57,481
Climb to 50,000' at 1.5M max. thrust A/B lit	12.0	0.83	750	56,731
Combat at 1.5M at 50,000' max. thrust A/B lit	-	5.0	3060	52,335*
Cruise back @ M = 0.905 at optimum alt. (39,000')	506.0	58.7	5500	46,835
Loiter over base at 39,000' at max. endurance speed	-	15.0	1250	45,585
Descend to sea level @ idle thrust	-	4.05	204	45,381
Land with reserves for 5 min. loiter at sea level at max. endurance speed	-	5.0	825	44,556
TOTAL	1012.0	146.02	21,613	

Fuel density = 7.8 lb./gallon

* 1,336 lb. missiles fired at combat

SECRET

TABLE 4 - ARROW 2 WITH IROQUOIS SERIES 2 ENGINES

SUPERSONIC (1.5M) HIGH ALTITUDE MISSION - SUPERSONIC (1.5M) COMBAT

CONDITION	DIST. N.M.	TIME MIN.	FUEL LBS	A/C WT. lb.
Start weight.	-	-	-	67,505
Engine start.	-	0.5	100	67,405
Take-off to unstick at sea level max. thrust A/B unlit.	-	0.32	192	67,213
Acc. to .92 M at S.L. Max thrust A/B unlit.	7.5	1.10	815	66,398
Climb @ .92 M to 35,000' Max thrust, A/B lit.	12.2	1.50	1,840	64,558
Acc. to 1.5 M at 35,000' Max thrust, A/B lit.	15.8	1.39	1,270	63,288
Climb @ 1.5M to 50,000' Max thrust, A/B lit.	14.5	0.98	860	62,428
Cruise out @ 1.5M at 50,000'	308.0	21.5	7,280	55,148
Combat @ 1.5M at 50,000' Max thrust, A/B lit.	-	5.0	3,060	50,752 *
Cruise back @ .905M at optimum altitude (39,000')	358.0	41.4	3,917	46,835
Loiter over base at 39,000' at max. endurance speed.	-	15.0	1,250	45,585
Descend to S.L. at idle thrust.	-	4.05	204	45,381
Land with reserves for 5 min. loiter at max. endurance speed at S.L.	-	5.0	825	44,556
	716.0	97.74	21,613	

Fuel density = 7.8 lb/gallon.

* 1336 lb missiles fired at combat

TABLE 4A- ARROW 2 WITH IROQUOIS SERIES 2 ENGINES

SUPERSONIC (1.8M) HIGH ALTITUDE MISSION - SUPERSONIC (1.8M) COMBAT

CONDITION	DIST. N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start weight	-	-	-	67,505
Engine start	-	0.5	100	67,405
Take-off to unstick at sea level max thrust, A/B unlit.	-	0.32	192	67,213
Acc. to 0.92 M at S.L. max. thrust, A/B unlit.	7.5	1.10	815	66,398
Climb @ 0.92 M to 35,000' max thrust A/B lit.	12.2	1.50	1,840	64,558
Acc. to 1.80 M @ 35,000' max thrust A/B lit.	26.0	2.0	1,970	62,588
Climb @ 1.8 M to 53,000' max thrust A/B lit.	17.7	1.03	1,028	61,560
Cruise out @ 1.8 M @ 53,000' partial A/B	274.6	16.0	6,240	55,320
Combat @ 1.8M@53,000' max thrust A/B lit.	-	5.0	3,450	50,534 *
Cruise back at .905 M at optimum altitude (39,000')	338	39.1	3,699	46,835
Loiter over base at 39,000' at max. endurance speed.	-	15.0	1,250	45,585
Descend to S.L. at idle thrust	-	4.05	204	45,381
Land with reserves for 5 min. loiter at max. endurance speed at S.L.	-	5.0	825	44,556
	676	90.6	21,613	

Fuel density = 7.8 lb/gallon.

* 1336 lb. missiles fired at combat.

SECRET

ARROW 2 WITH IROQUOIS SERIES 2 ENGINES

TABLE 5 COMBAT AIR PATROL - SUPERSONIC COMBAT (1.5 M)

CONDITION	DIST. N.M.	TIME MINS.	FUEL LB.	A/C WT. LB.
Start Weight	--	--	--	71,747
Engine Start	--	0.5	100	71,647
Take-off to unstick at sea level maximum thrust, A/B unlit	--	0.35	215	71,432
Acc. to 527 Kts. at S.L., max thrust A/B unlit	5.6	0.93	674	70,758
Climb at 527 Kts. to 35,000' max thrust A/B unlit (opt. cruise out alt.)	45.0	5.14	2150	68,608
Cruise out at 0.905Mat 35,000'	544.0	62.4	7997	60,269+
Acc. to 1.5 M at 35,000' max thrust A/B lit	14.8	1.28	1180	59,089
Climb to 50,000' at 1.5 M, max thrust A/B lit	13.6	0.86	805	58,284
Combat at 50,000' at 1.5 M, max thrust A/B lit	--	5.0	3060	53,888*
Cruise back at .905 M at optimum alt. (39,000')	623	72.08	7053	46,835
Loiter over base at 39,000' at max endurance speed	--	15.0	1250	45,585
Descend to S.L. at idle thrust	--	4.05	204	45,381
Land with reserves for 5 min loiter at S.L. at max end. speed	--	5.0	825	44,556
TOTAL	1246	172.59	25,513	

Fuel density 7.8 lb/gallon
+ 342 lb. ventral D.T. Jettisoned
* 1336 lb. missiles fired at combat.

SECRET

ARROW 2 WITH IROQUOIS SERIES 2 ENGINES

UNCLASSIFIED

Table 6 - SUBSONIC LOW LEVEL MISSION (10,000') - SUBSONIC COMBAT

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight				67,505
Engine Start		0.50	100	67,405
Take-off to Unstick at S.L. Max Thrust A/B Unlit		0.32	192	67,213
Acc. to 527 K. at S.L. Max. Thrust A/B Unlit	5.0	0.85	609	66,604
Climb at 527 K. TAS to 10,000' Max. Thrust A/B Unlit	6.0	0.72	490	66,114
Cruise at M=0.70 at 10,000' (Opt. Cruise Speed)	381.0	51.20	9280	56,834
Acc. to M=0.92 at 10,000' Max. Thrust A/B Unlit	4.0	0.43	260	56,574
Combat at M=.92 at 10,000' Max. Thrust A/B Unlit		5.0	3140	52,098 x
Climb to 39,000' at 527 KTS TAS Max. Thrust A/B Unlit	30.0	3.7	1240	50,858
Cruise back at M=0.905 at optimum Altitude (39,000 ft.)	366.0	42.4	4023	46,835
Loiter over base at 39,000 ft. at max. endurance speed		15.0	1250	45,585
Descend to S.L. at idle thrust		4.05	204	45,381
Land with reserves for 5 mins.				
Loiter at S.L. at Max. Endurance Speed		5.0	825	44,556
TOTAL	792	129.17	21,613	

Fuel density 7.8 lb./gallon.

x 1336 lb. missiles fired at combat.

SECRET

ARROW 2 WITH IROQUOIS SERIES 2 ENGINES

TABLE 7 - FERRY MISSION (NO ARMAMENT)

VENTRAL TANK CARRIED THROUGHOUT

CONDITION	DISTANCE (N.M.)	TIME (MIN.)	FUEL (LB.)	A/C WEIGHT (LB.)
Start Weight	-	-	-	70,411
Engine Start	-	0.50	100	70,311
Take-Off to Unstick, Max. Thrust, A/B Unlit	-	0.34	205	70,106
Acc. to 527 Kts. at S.L., Max. Thrust, A/B Unlit	5.5	0.91	656	69,450
Climb to 35,000' at 527 Kts. T.A.S. Max. Thrust, A/B Unlit	43.5	5.0	2,100	67,350
Cruise Climb to 40,000' at M = .905	1451.0	168.2	20,052	47,298
Loiter over Base at 40,000' at Max. Endurance Speed	-	15.0	1,330	45,968
Descend to S.L. at Idle Thrust	-	4.1	205	45,763
Land with Reserves for 5 Mins. Loiter at S.L. at Max. Endurance Speed	-	5.0	865	44,898
TOTAL	1,500	199.05	25,513	

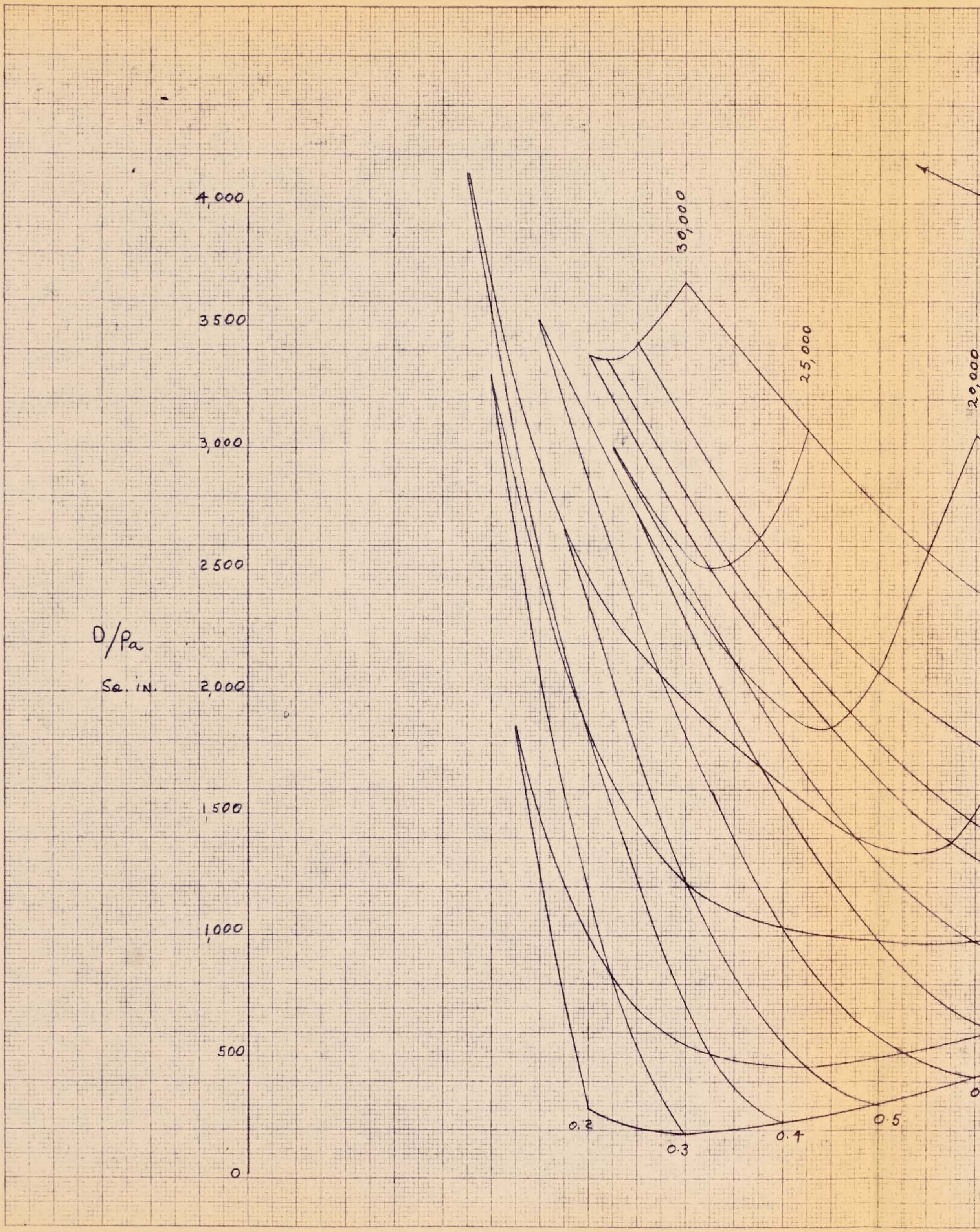
Fuel Density = 7.8 lb./gallon

SECTION 2 DRAG DATA

The drag data used in this report are presented in the form of D/p_a, W/p_a vs M carpets in the following four figures. They are based on a mean c.g. position of 29.5% $\bar{\bar{c}}$.

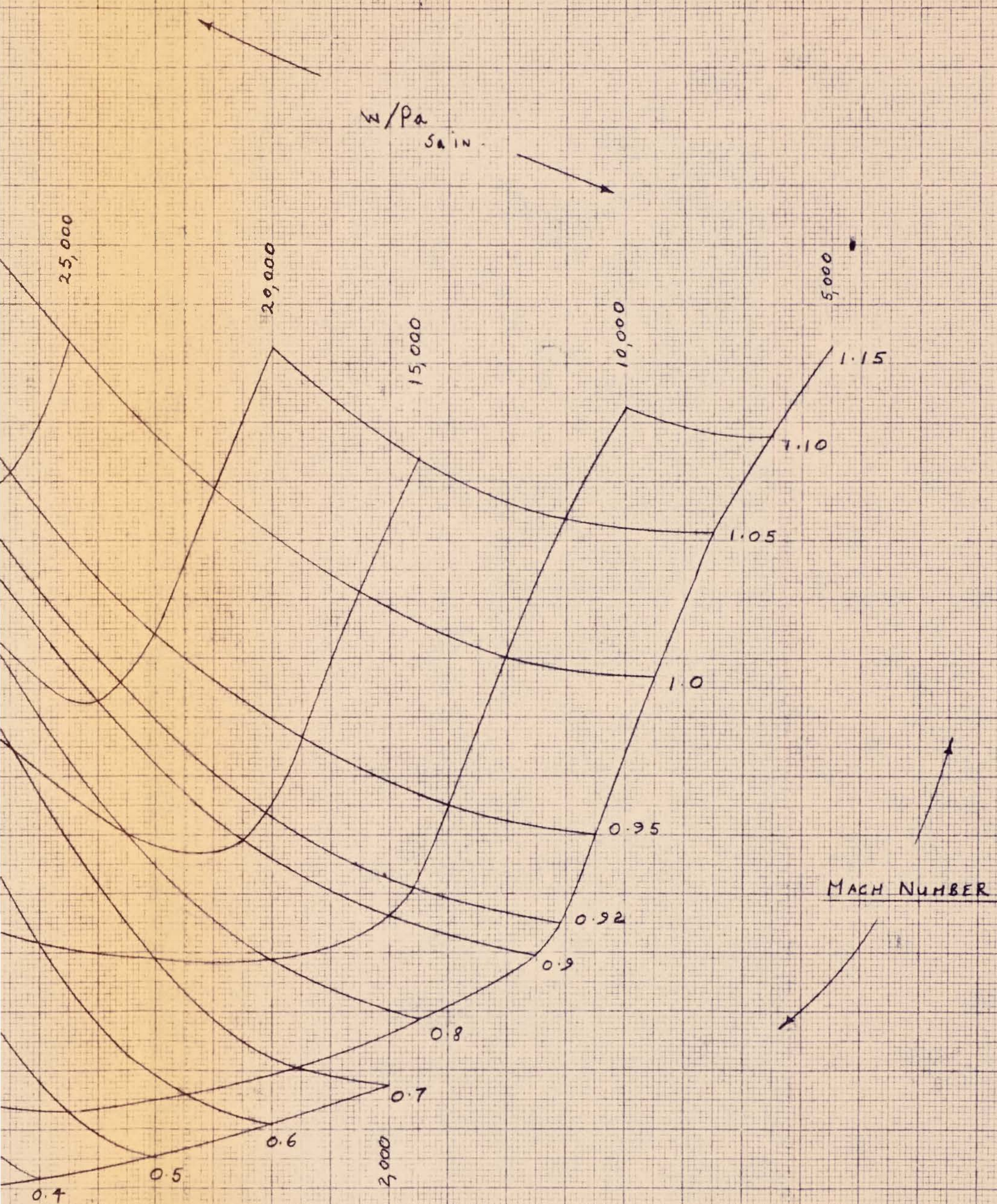
Basically, the estimated data of Periodic Performance Report Number 12 have been modified in the light of flight tests carried out on Aircraft 25202 and 25203.

Aircraft 25203 was partially instrumented for performance flight testing, and carried out some preliminary performance tests. In view of the approximate nature of the tests, a conservative view was maintained whilst analysing the results, and the drag reductions claimed are considered to be the minimum as evidenced by the tests. The drag reductions are considered in two fields only: (1) a reduction in negative elevator angle to trim, and hence in transonic trim drag, between Mach numbers of 0.80 and 1.2. (2) a reduction in boat tail drag over the whole supersonic range.



D/Pa
Sq. in.
4,000
3500
3,000
2500
2,000
1,500
1,000
500
0
30,000
25,000
20,000
0.2
0.3
0.4
0.5

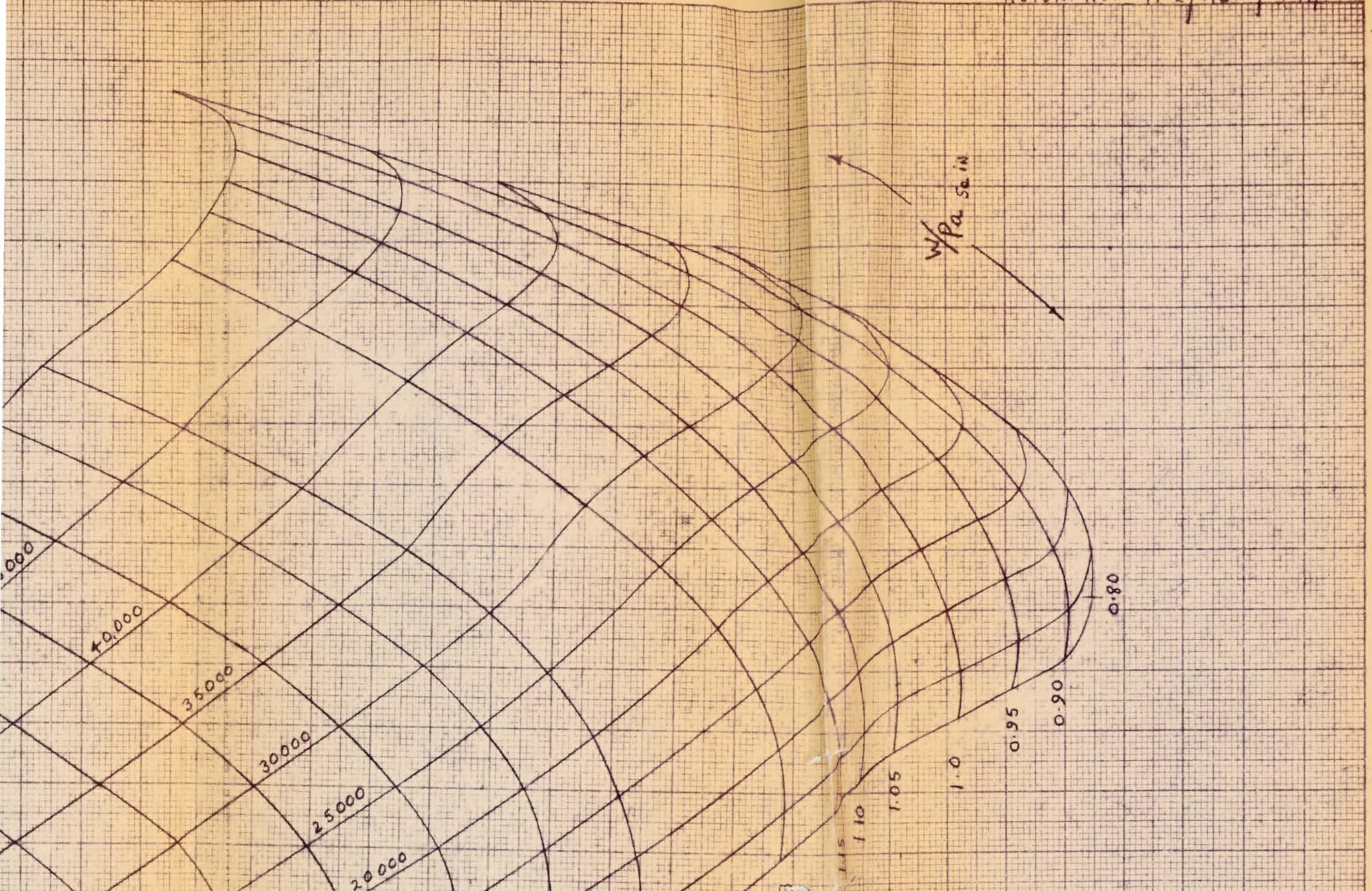
REVISED ARROW D/Pa Vs W/Pa & M. NUMBER



Nov/58

FIG 10

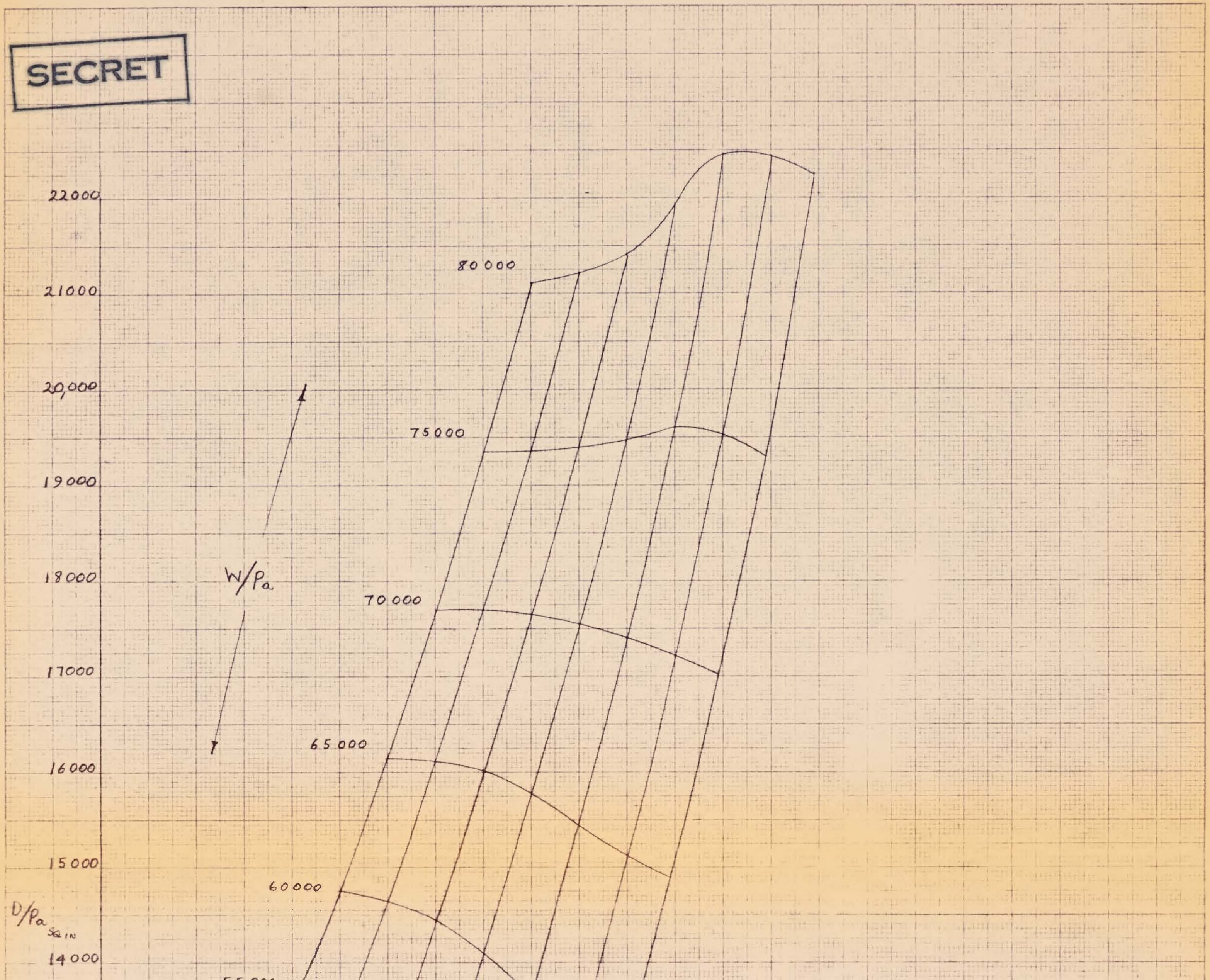
Oct/58



D/Pa INS²
10,000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
MACH NUMBER
2.0
1.9
1.8
1.7
1.6
1.5
1.41
1.23
1.15
1.10
1.05
1.0
0.95
0.90
0.80
1000
5000
10000
15000
20000
25000
30000
35000
40,000
W/Pa SQ IN
UNCLASSIFIED

FIG. 11.

SECRET

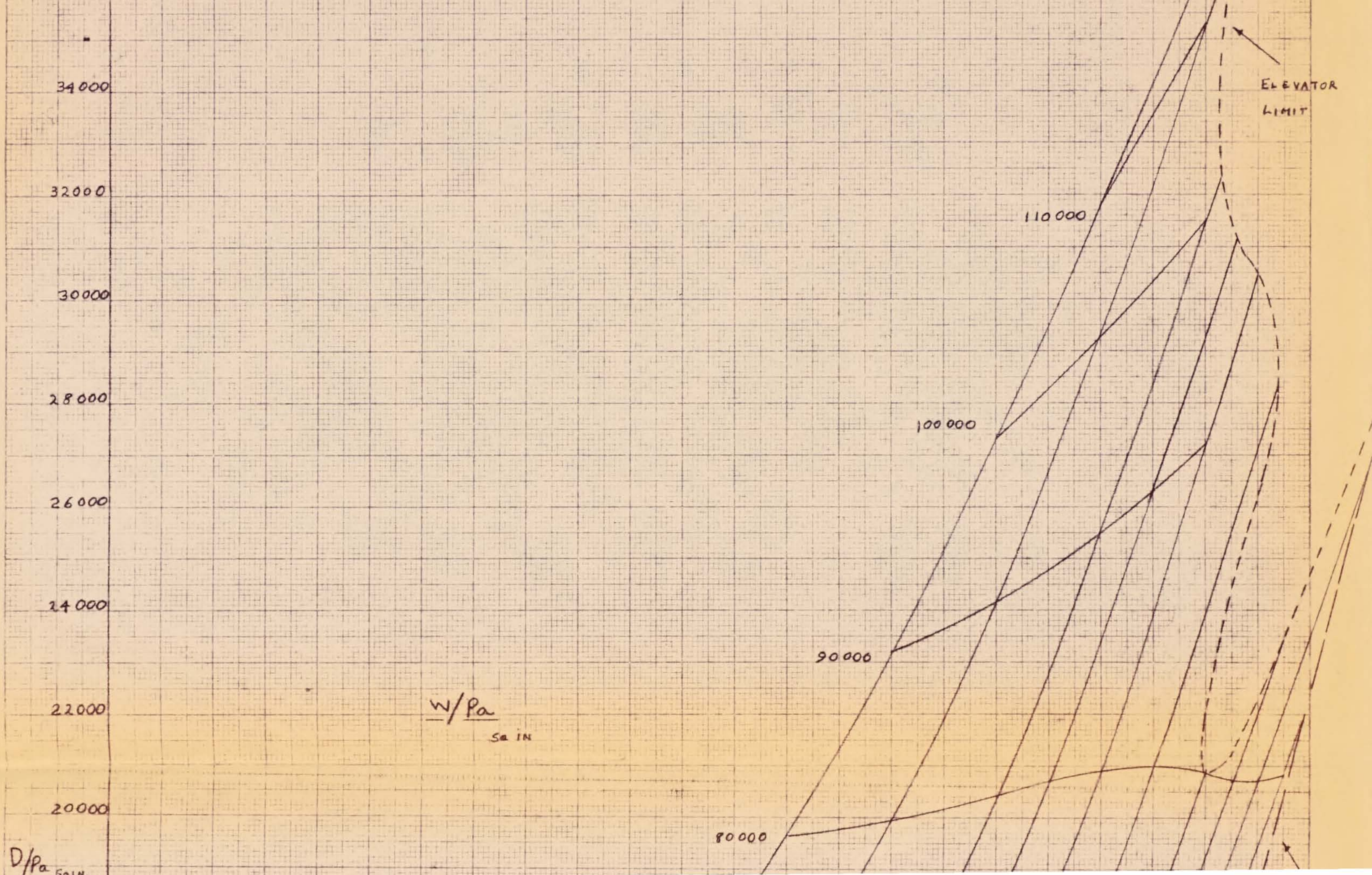

22000
21000
20,000
19000
18000
17000
16000
15000
14000
D/Pa SQ IN
W/Pa
80 000
75000
70 000
65 000
60000

SECRET

REVISED ARROW D/Pa Vs W/Pa & M. NUMBER

4° UP AILERON DEFLECTION (ABOVE 45,000 FT.)

C.G. 29.5% M.A.C.



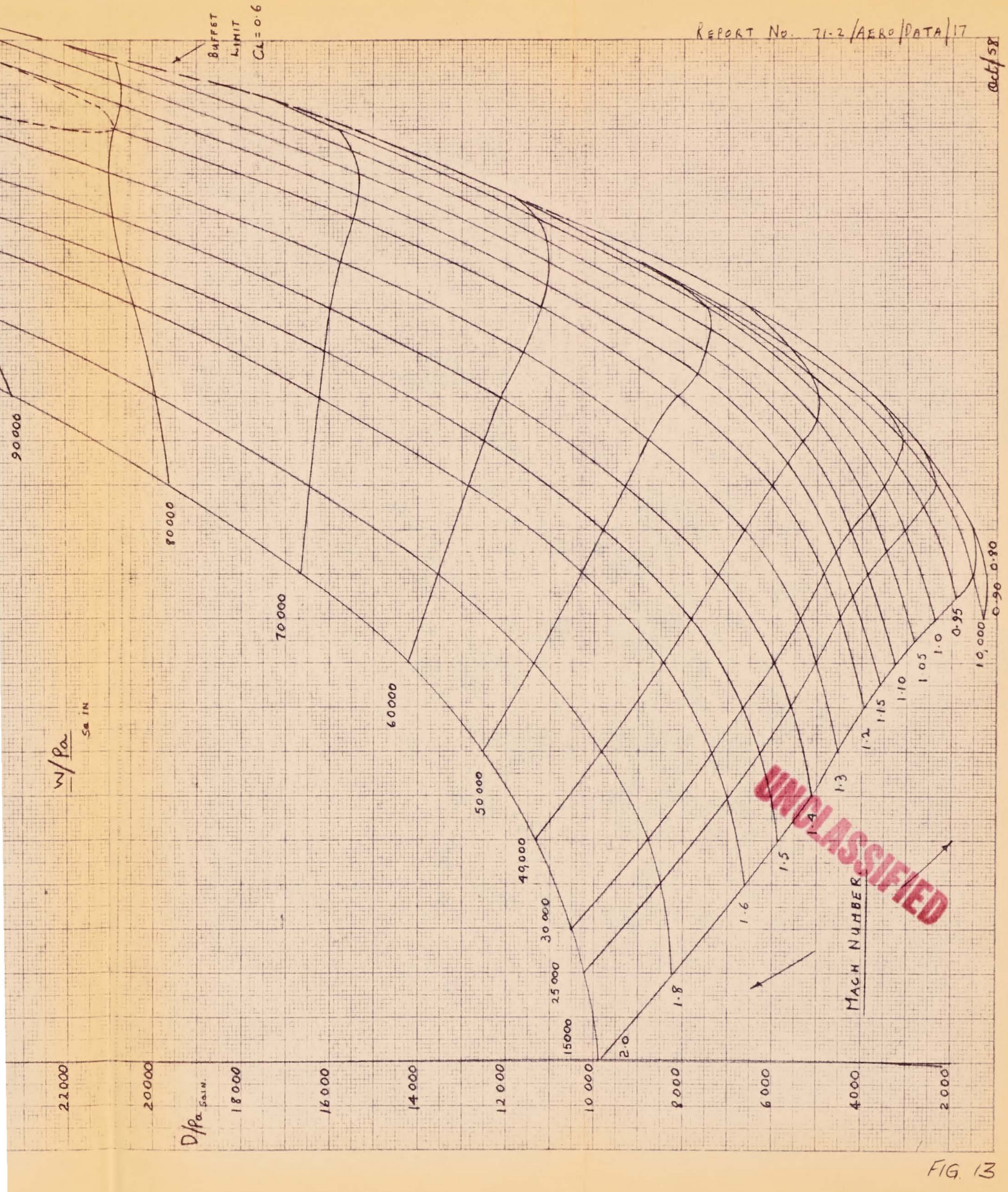

BUFFET LIMIT
CL = 0·6
W/Pa SQ IN
D/Pa SQ IN.
90 000
80 000
70 000
60 000
50 000
40,000
30 000
25 000
15000
10,000
2·0
1·8
1·6
1·5
1·4
1·3
1·2
1·15
1·10
1·05
1·0
0·95
0·90
0·80
MACH NUMBER
22 000
20 000
18 000
16 000
14 000
12 000
10 000
8 000
6 000
4 000
2 000

FIG. 13

SECTION 3 PROPULSION DATA

Introduction

The changes within the Arrow 2/Iroquois propulsion system between publication of P.P.R. 14 and P.P.R. 15 are:- (a) A decrease in maximum high pressure rotor speed from 8150 to 8050 r.p.m. but with identical rotor swallowing capacity. (b) The introduction of a high pressure rotor control rather than a low pressure rotor control such that at free stream total temperatures greater than 288°K there is a drop in low pressure rotor speeds. Thus above M = 1.278 above the tropopause there is a drop in engine swallowing capacity. (c) A reduction in the variable restrictor flow area in the closed position to give small improvements in subsonic performance and significant improvements in distortion levels.

Both reports contain identical intake and ejector geometry, afterburner fuel schedule, and afterburner efficiency.

Prepared by Internal Aero. Group - Nov. 1958.

SECRET

Ref: 72/Int Aero/33

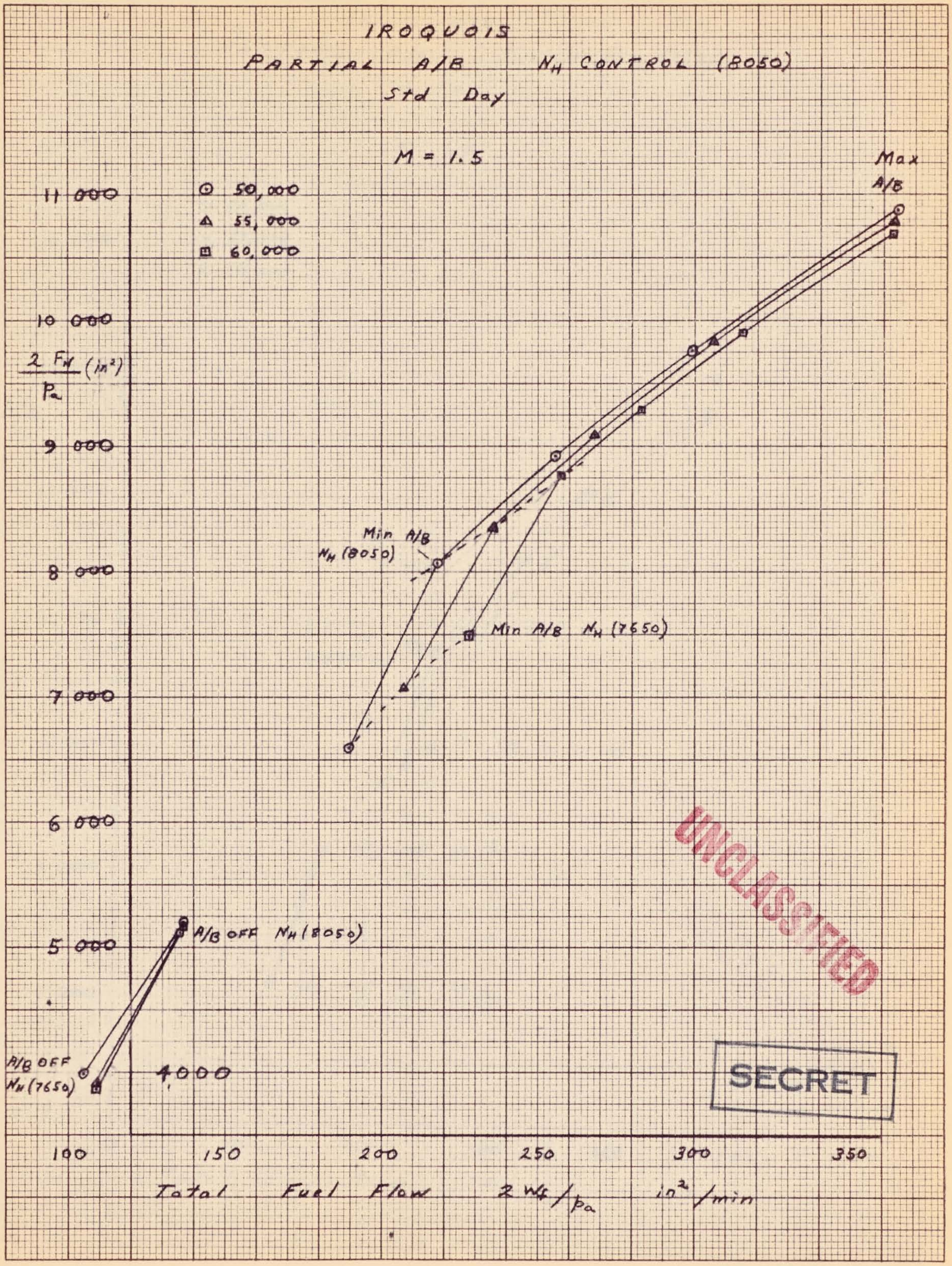


FIG. 16

Ref: 72/Int Aero/133

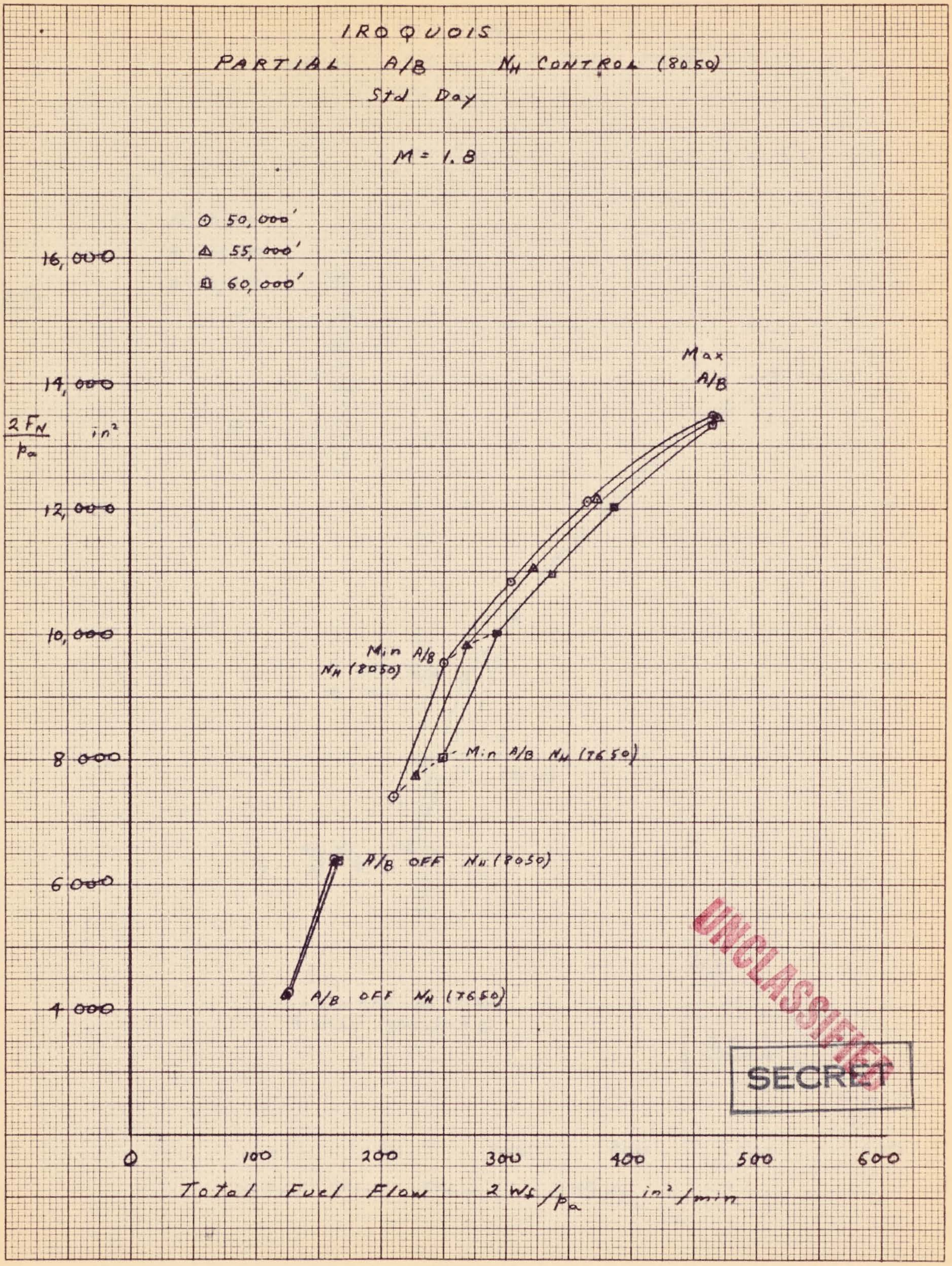
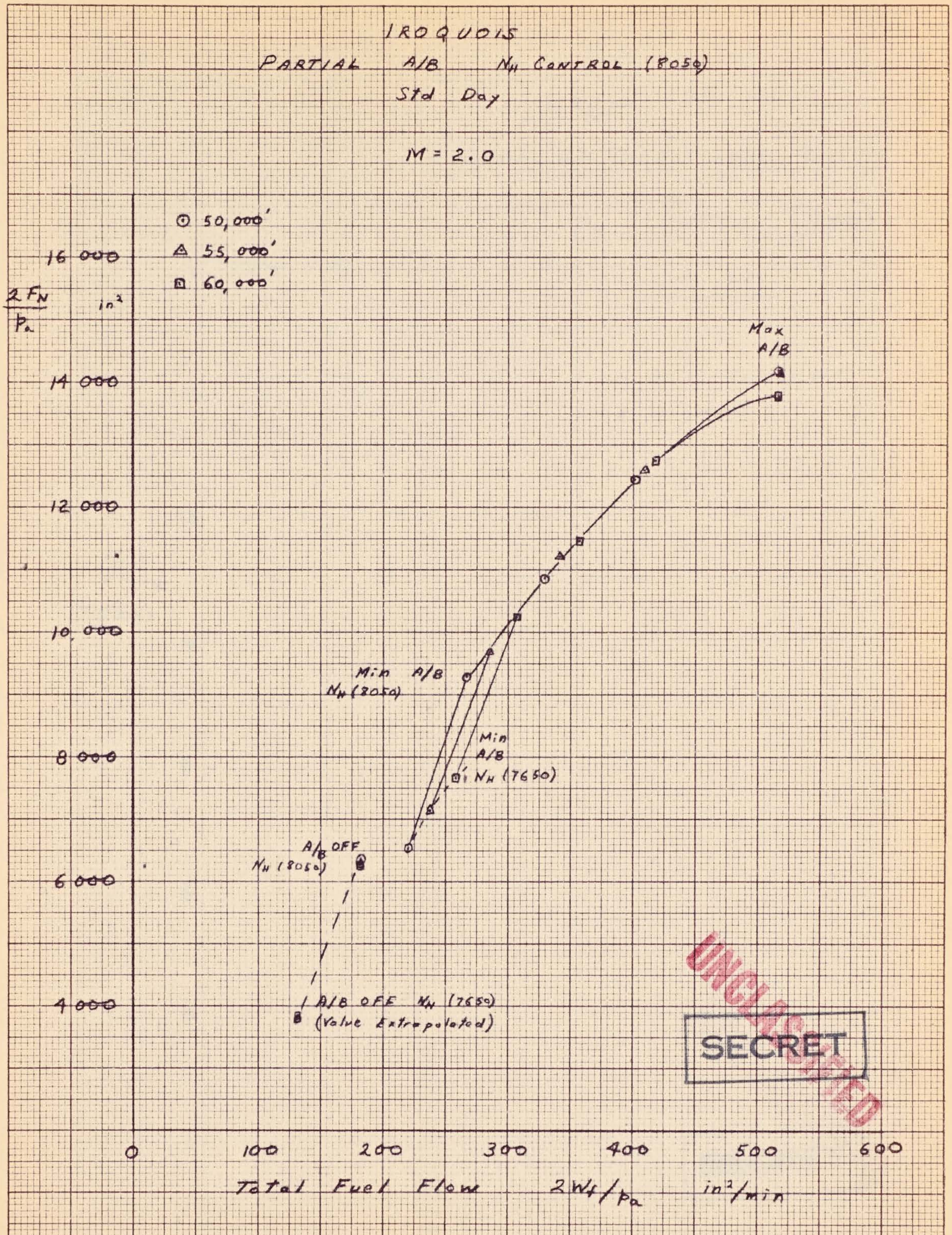


FIG. 17.

Ref: 72/Int Aero/33



SECRET

UNCLASSIFIED

FIG. 18.

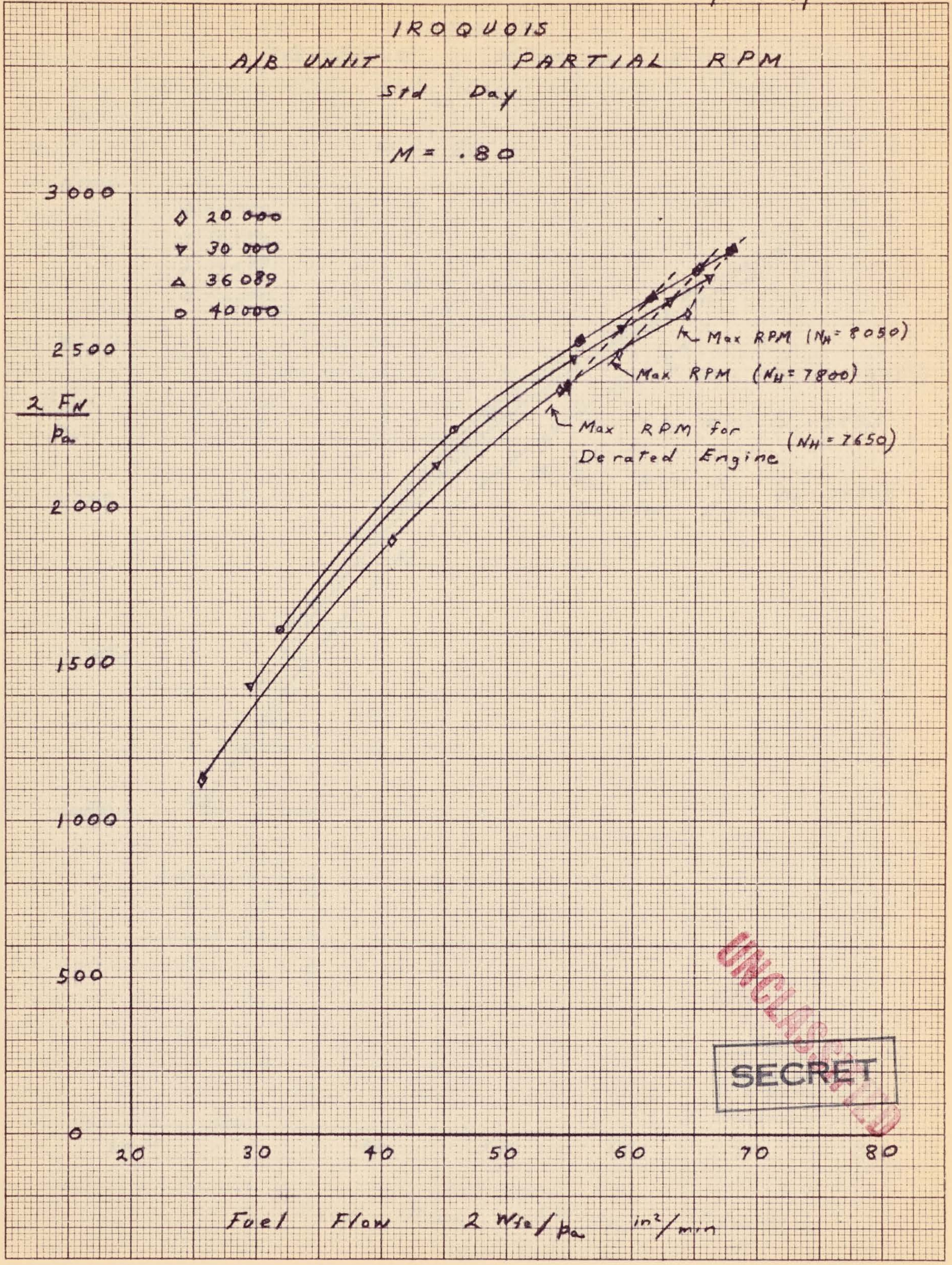

IROQUOIS
A/B UNIT PARTIAL RPM
Std Day
M = .80
3000
2500
2000
1500
1000
500
0
◊ 20 000
▽ 30 000
△ 36 089
○ 40 000
2 FN / Pa
Max RPM (NH = 8050)
Max RPM (NH = 7800)
Max RPM for Derated Engine (NH = 7650)
20
30
40
50
60
70
80
Fuel Flow 2 Wfe / Pa in²/min

FIG 21.

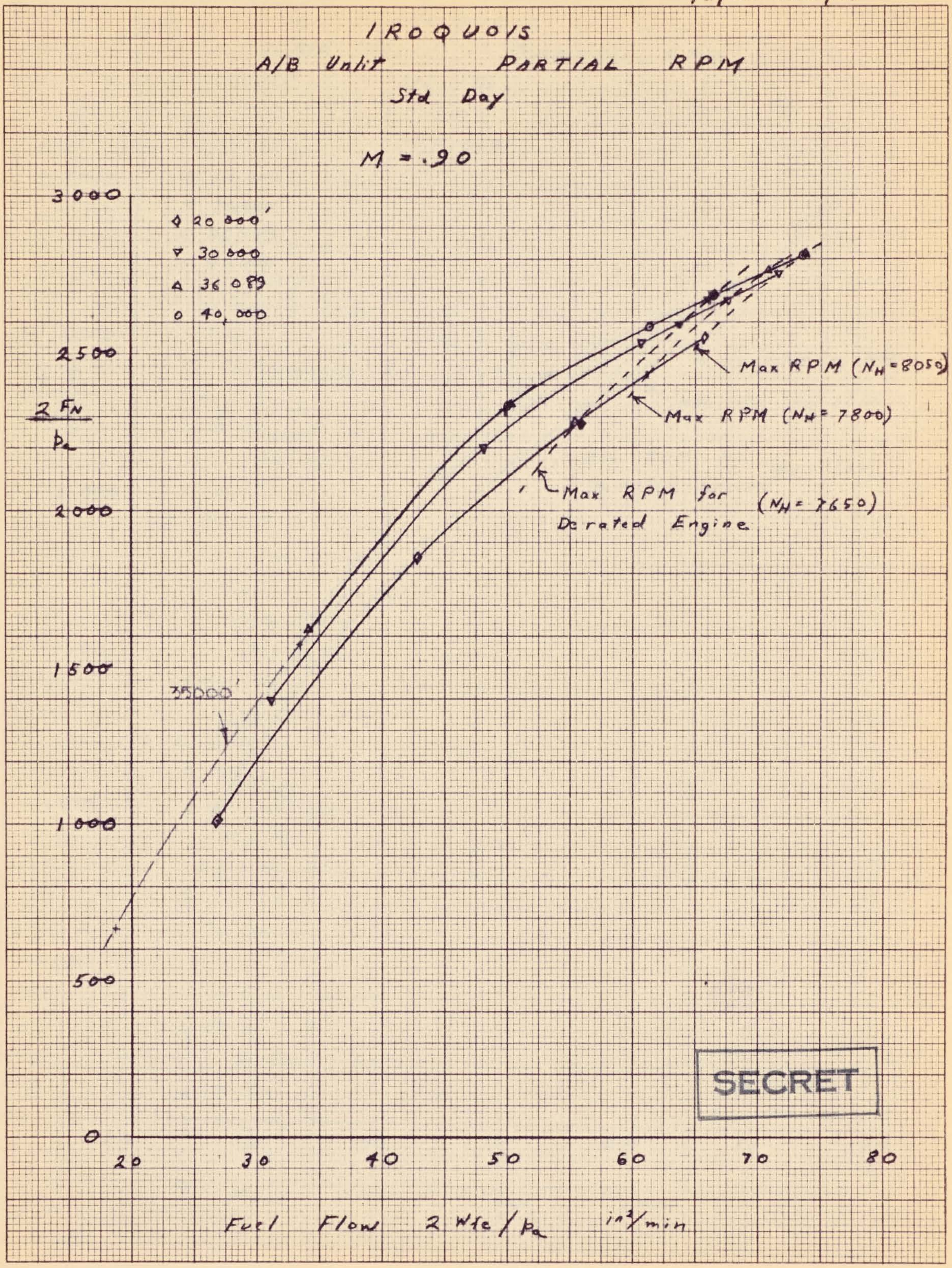

IROQUOIS
A/B Unit PARTIAL RPM
Std Day
M = .90
◊ 20 000'
▽ 30 000
△ 36 089
○ 40,000
35000'
Max RPM (N_H=8050)
Max RPM (N_H=7800)
Max RPM for Derated Engine (N_H=7650)
3000
2500
2000
1500
1000
500
0
20
30
40
50
60
70
80
2 FN / pa
Fuel Flow 2 Wfe / pa in³/min
SECRET

FIG. 23. 19a.

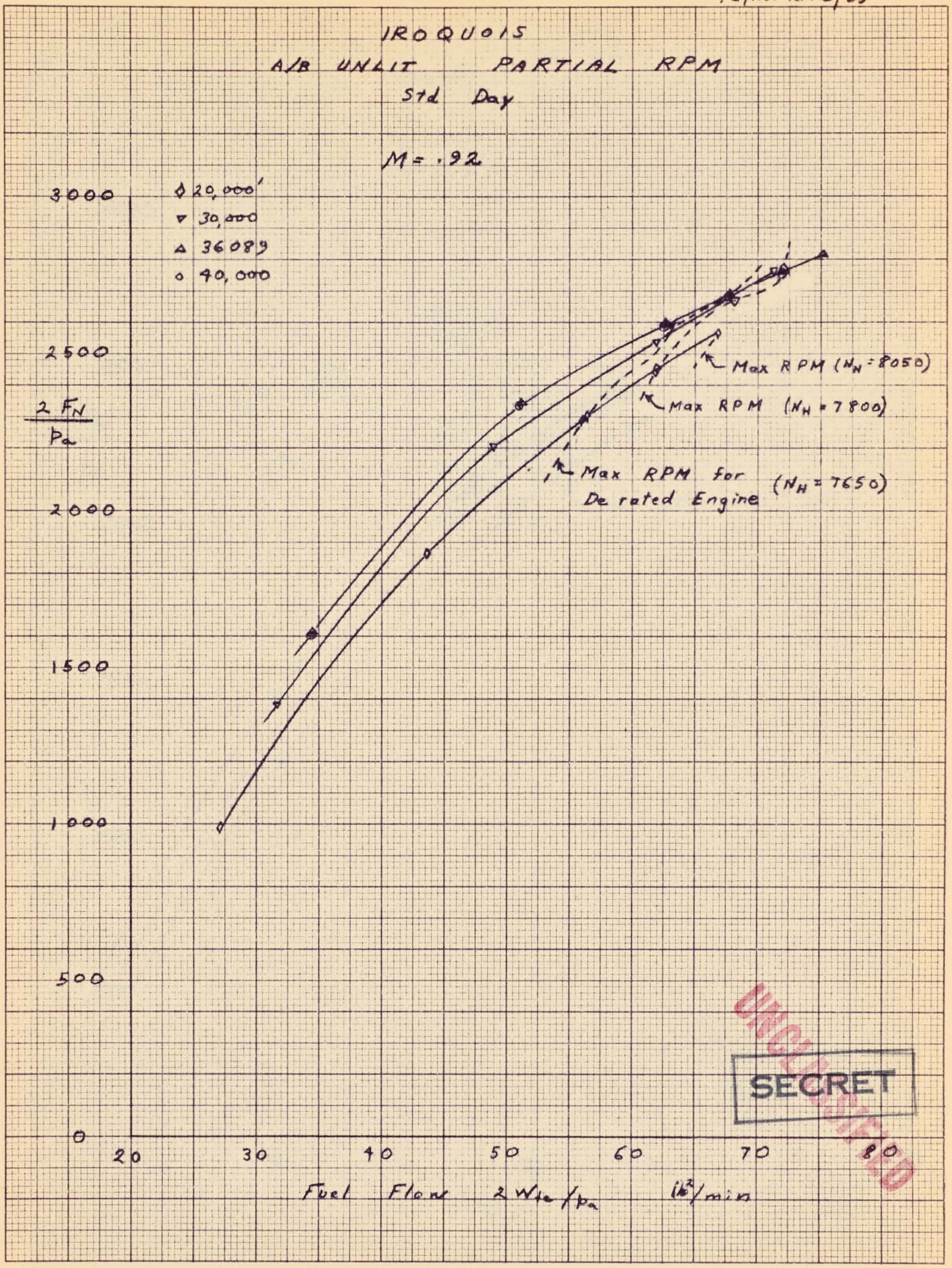
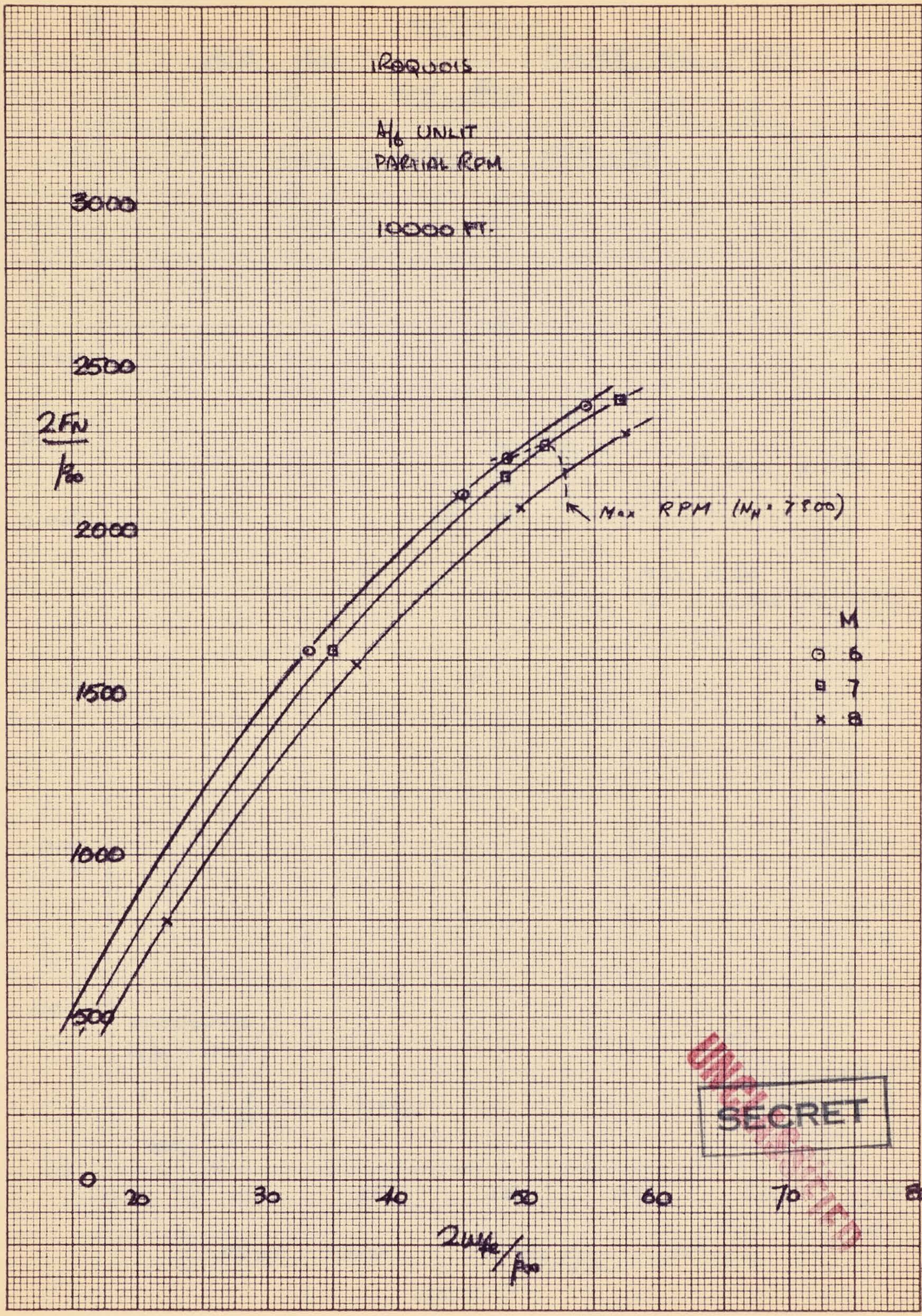

IROQUOIS
A/B UNLIT PARTIAL RPM
Std Day
M = .92
◊ 20,000'
▿ 30,000
△ 36089
○ 40,000
2 FN / Pa
3000
2500
2000
1500
1000
500
0
20
30
40
50
60
70
80
Fuel Flow 2 Wfe/pa lb²/min
Max RPM (NH = 8050)
Max RPM (NH = 7800)
Max RPM for De rated Engine (NH = 7650)
SECRET
UNCLASSIFIED

FIG 25.

72./INT. AERO/33



SECRET

UNCLASSIFIED

FIG. 26.

Ref: 72/Int aero/33

IROQUOIS

A/B UNLIT — PARTIAL R.P.M.

Std. Day

SEA LEVEL M = .40

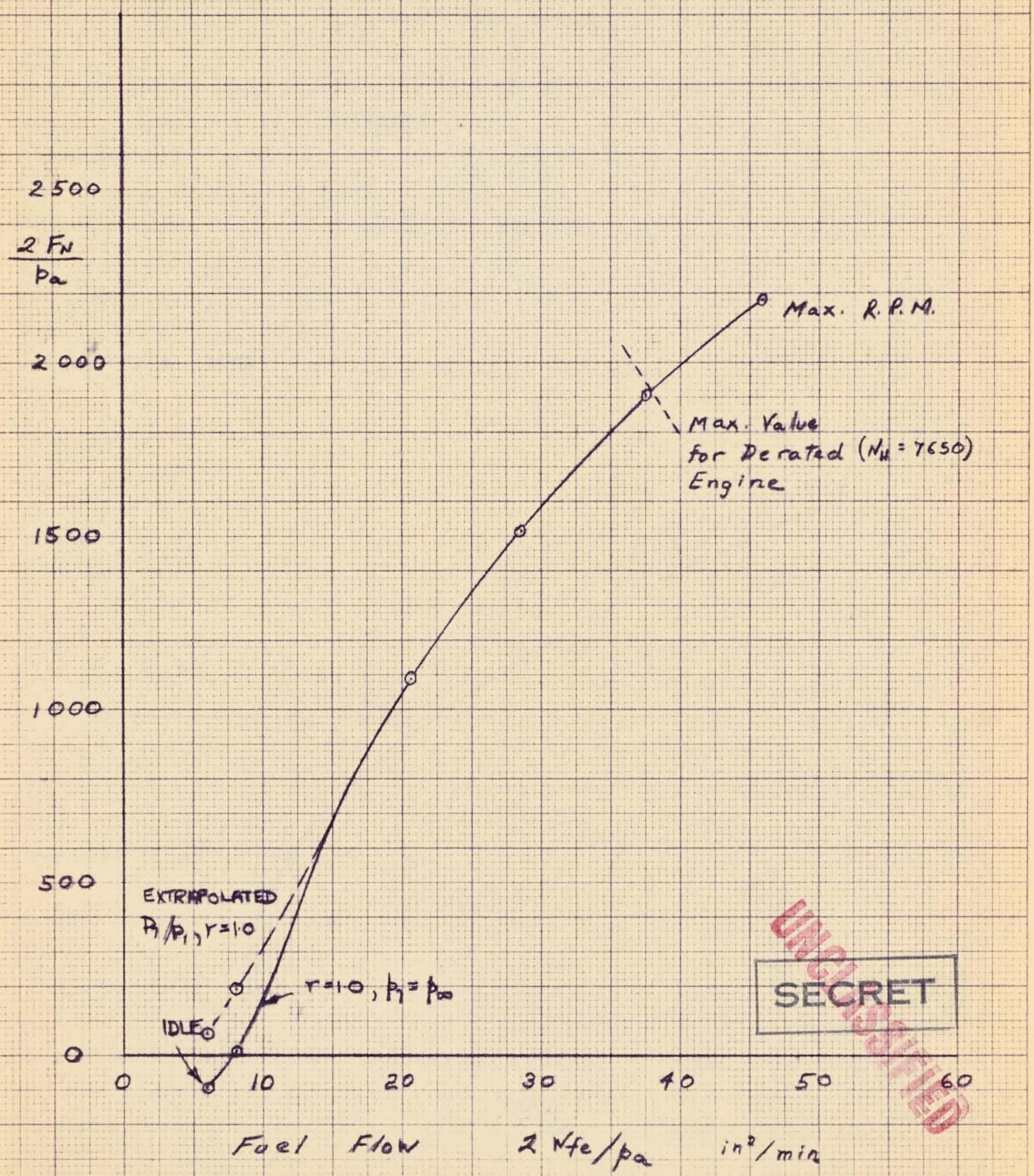


FIG. 27

72/INT. AERO/33

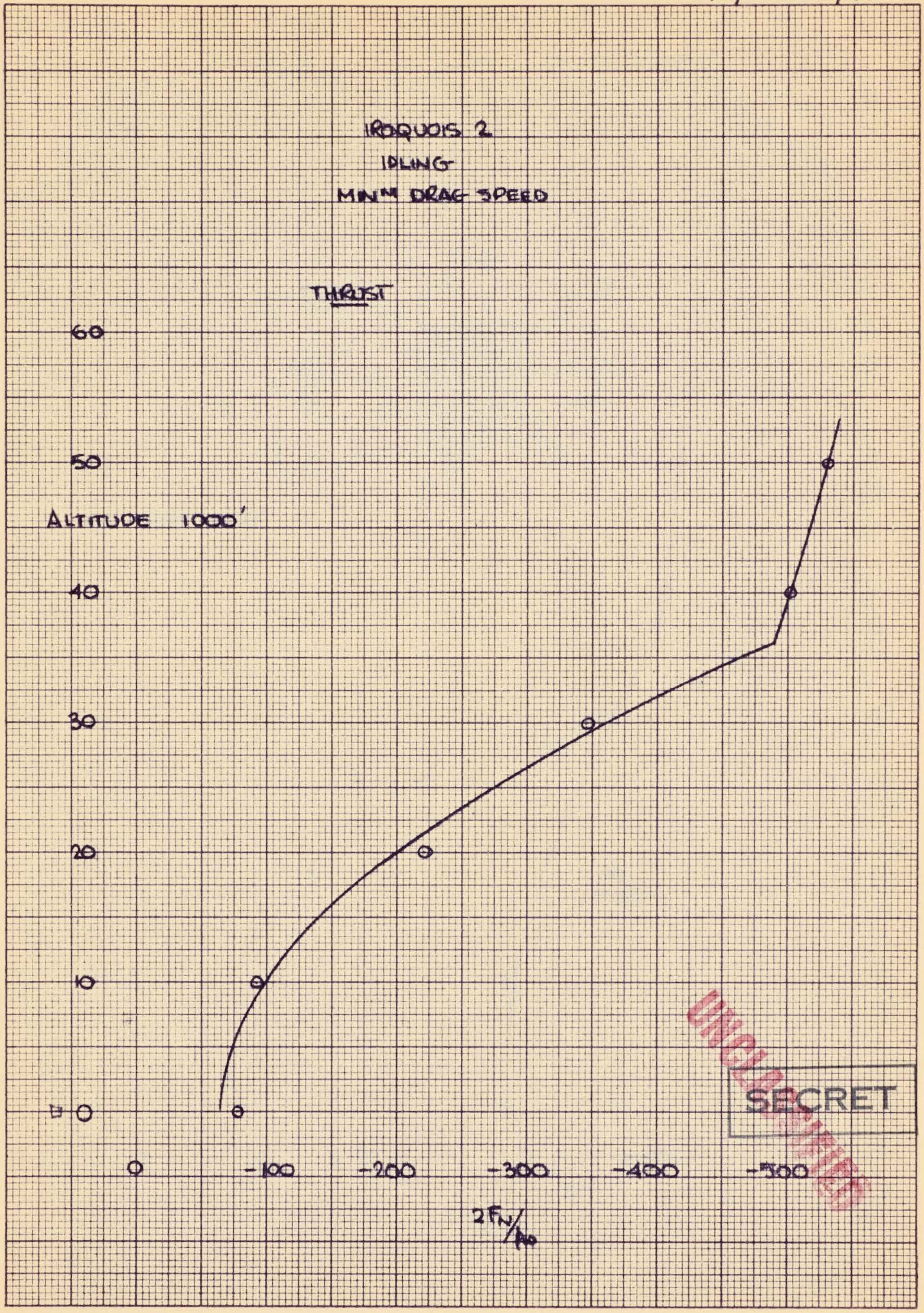
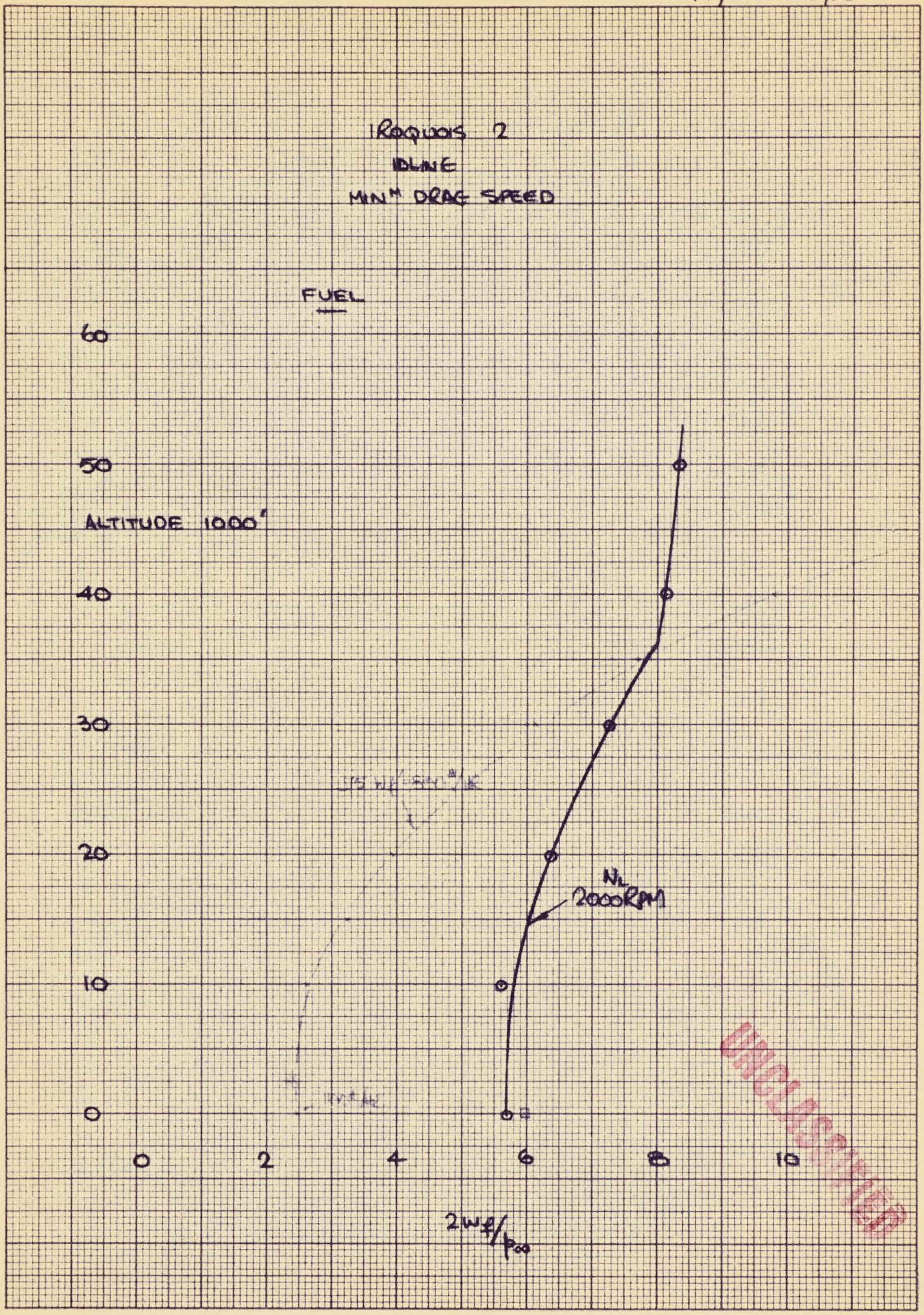


FIG. 28



IROQUOIS 2
IDLING
MINM DRAG SPEED
FUEL
ALTITUDE 1000'
60
50
40
30
20
10
0
0
2
4
6
8
10
NL
2000RPM
2Wf/P00

FIG. 29.

SECRET

DEVELOPMENT PROGRAM PROJECTS OF A CONTINUING NATURE

The detailed cost forecast attached indicates the cost of carrying certain continuing Development projects further than will be possible under the Development Program which terminates September 30, 1960.

In our view, the Development Program should terminate with the delivery of the first operational aircraft and, accordingly, we have limited the statement of work for the Development Program to that date. It will be appreciated, however, that certain engineering testing and evaluation work, other than Engineering Support to Production, which stems from the Development Program would normally continue for some time in parallel with squadron production. Accordingly, we have shown those items which might be covered under separate contract provision (similar to the Project K arrangements on the CF-100 Program) if the RCAF and DDP so request.

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WORK IN PRODUCT IMPROVEMENT CONTRACT WHICH COULD BE CARRIED ON AFTER SEPTEMBER 30, 1960

	Oct.1/Mar.31 1960/1961	1961/1962	TOTAL
	$	$	$
1.1 Preliminary engineering of the Arrow Aircraft	50,000	33,600	83,600
4.1.3 Design, specification and operation of systems analysis and flight simulation aids, including analog computer, for use in stability, control, autopilot and airframe systems problems. Operation of cockpit simulator and flying control test rig in conjunction with analog computer shall be included.	75,000	26,250	101,250
4.2.4 Structural and systems ground testing including the design and specification of test specimens and the design and construction of test rigs and facilities. Major items covered by this paragraph are: (a) Arrow 1 and 2 air conditioning. (b) Arrow 1 and 2 fuel system (c) Flying controls. (d) Landing gear (e) Static test aircraft (f) Genie/Falcon weapon pack including ground firing.	150,000	52,500	202,500
4.3.2 Instrumentation for Avro flight test program: (a) Design and specification of airframe sensing and airborne data recording instrumentation. (b) Design of instrumentation installation including the manufacture of special parts for mounting, and installation, check-out and calibration of instrumentation. (c) Design, provision and installation of changes to airborne instrumentation. (d) Maintenance of airborne instrumentation.	250,000	157,500	407,500
4.3.5 Instrumentation for Orenda Engines Limited flight test program: (a) Design of the installation of airborne data recording instrumentation. (b) Installation, check-out and calibration of instrumentation. (c) Assistance with the maintenance of and changes to instrumentation.	35,000	26,250	61,250

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	Oct.1/Mar.31 1960/1961	1961/1962	TOTAL
	$	$	$
4.3.6 Instrumentation for RCAF flight test program. (a) Design and specification of airframe sensing and airborne data recording instrumentation. (b) Design of instrumentation installation including the manufacture of special parts for mounting, and installation, check-out and calibration of instrumentation.	50,000	31,500	81,500
4.4.1 Planning and conduct of the Avro flight test program including: (a) Detail planning of test programs. (b) Specification of required instrumentation for specific flights. (c) Recording and reduction of flight test data. (d) Pre-flight testing (e) Provision of flight crews. (f) Briefing and debriefing of flight crews. (g) Supply of flight test data to Orenda Fngines Limited.	600,000	210,000	810,000
4.4.3 Maintenance and operation at Malton by Avro of aircraft 25201 through 25214 together with two Sabre 6 and one CF-100 Mk.5 chase aircraft. This shall include: (a) Maintenance and operation of MA-1 electronic system, Genie rockets and Falcon missiles. (b) Supply of fuel and oil. (c) Procurement of maintenance assistance from sub-contractors other than Hughes Aircraft Company. (d) Support to RCAF Phase 2 program on one Arrow 1 aircraft. (For procurement of HAC technical assistance see 13.8)	1,400,000	525,000	1,925,000

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	Oct.1/Mar.31 1960/1961	1961/1962	TOTAL
4.5.2 Conduct of an aircraft/FCS/weapon development program at a base to be designated by the RCAF on three Arrow 2 aircraft equipped with Genie/Falcon weapon packs including:	600,000	315,000	915,000
4.5.3 Support of RCAF evaluation programs at a base to be designated by the RCAF on six Arrow 2 aircraft fitted with Genie/Falcon weapon packs including:	550,000	262,500	812,500

4.5.2
Conduct of an aircraft/FCS/weapon development program at a base to be designated by the RCAF on three Arrow 2 aircraft equipped with Genie/Falcon weapon packs including:

(a) Maintenance and operation of three Arrow 2 aircraft for approximately nine months.

(b) Provision of personnel to support the flight test program.

(c) Provision of technical assistance from major sub-contractors.

(d) Provision of GSE.

(e) Provision of modifications to enable each of these aircraft to be used as targets when necessary.

(f) Provision of mobile repair parties and modification kits to conduct necessary changes to these aircraft during the program.

4.5.3
Support of RCAF evaluation programs at a base to be designated by the RCAF on six Arrow 2 aircraft fitted with Genie/Falcon weapon packs including:

(a) Provision of personnel to assist the evaluation program.

(b) Provision of technical assistance from major sub-contractors.

(c) Provision of maintenance for airborne instrumentation.

Note 1: Aircraft allocation to this program will be four to six aircraft, depending on need for attrition replacements. See aircraft allocation chart.

Note 2: For provision of mobile repair and maintenance parties, service representatives and modification kits to support this operation see 3.3.3., 11.4 and 12.23.

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	Oct.1/Mar.31 1960/1961	1961/1962	TOTAL
6.4 Provision of services and materials for maintenance appraisal and the collection and preparation of maintenance and logistics data on the airframe and associated GSE.	50,000	15,750	65,750
6.7 Preparation and publication of periodic Arrow program reports, as follows: (a) Quarterly physical report (b) Quarterly financial report (c) Monthly letter report.	45,000	16,800	61,800
6.8 Provision of Engineering data and reports on request from the RCAF including: (a) Performance and weights reports. (b) Ground and flight test reports. (c) Wind tunnel, strength and system reports.	35,000	21,000	56,000
6.11 Preparation and publication of special Weapon System Co-ordination reports.	12,000	-	12,000
6.12 Preparation and maintenance of Arrow 2 systems brochures. (Work terminated).	2,000	-	2,000
7.16 Study and analysis of technical problems with respect to GSM on request from the RCAF, and recommendations of solutions to these technical problems.	30,000	21,000	51,000
	$3,934,000	$1,714,650	$5,648,650